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22 March 1982

USSR Report

LIFE SCIENCES

BIOMEDICAL AND BEHAVIORAL SCIENCES

(FOUO 2/82)

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BIOCHEMISTRY

UDC: 577.1:547.963.3

CLONING OF DNA OF HEPATITIS VIRUS B IN ESCHERICHIA COLI

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 260, No 4, 1981 (manuscript received 14 May 81) pp 1022-1024

[Article by P. P. Pumpen, A. V. Dishler, T. M. Kozlovskaya, V. V. Bychko, E. Ya. Gren, M. B. Rivkina, A. P. Grinberg and R. A. Kukayn, academician of the Latvian Academy of Sciences, Institute of Organic Synthesis, Latvian Academy of Sciences, and Institute of Microbiology imeni Avgust Kirkhenshteyn, Latvian Academy of Sciences, Riga]

[Text] Hepatitis virus B consists of spherical particles, 42 nm in diameter [1], whose external membrane is made up mainly of so-called surface antigen (HB_sAg), while the nucleocapsid, 27 nm in diameter, consists of internal or core antigen (HB_cAg). In the nucleocapsid is contained double-stranded DNA, 3200 nucleotides in length, with a single break in one of the chains and an unoccupied segment 400 to 1500 nucleotides in length in the other [2, 3]. It is possible to build up the single-strand DNA segment in vitro by virtue of the presence in the nucleocapsid of endogenous DNA Polymerase [4], which utilizes the 3' end of the short chain as primer for synthesis.

Since blood plasma from patients with hepatitis B or chronic carriers of the virus are the only source of virus or its antigens, until recently there was extremely limited possibility of studying the structure of viral macromolecules and molecular mechanisms of replication, as well as of developing antiviral vaccine and diagnostic products. The situation changed because of the cloning of DNA of hepatitis virus B in *E. coli* as part of vectors derived from λ phage [5, 6] or plasmids [7-9], which was helpful primarily in the study of the structure of viral DNA. Determination of the nucleotide sequence in cloned DNA made it possible to localize the HB_sAg [9, 10] and HB_cAg [11] genes. At the present time, the complete sequence of DNA of hepatitis virus B of two subtypes is known: ayw [12] and adw₂ [13]. Moreover, expression of HB_cAg [11] and HB_sAg [14] genes in *E. coli* was obtained, and in the latter case the antigenic determinants of HB_sAg were contained in a large chimeric protein, 85% of whose sequence is referable to bacterial β -galactosidase. The level of production of such protein in bacterial cells is not high enough (about 0.05% of all protein), and it is notable for instability [14]. Consequently, the problem of expression of the genes of hepatitis virus B in bacteria cannot be considered definitively solved. Moreover, since differences were demonstrated in the DNA sequence of subtypes adw and adw₂ virus [12, 13], each new structure of DNA of hepatitis virus B is of definite interest. For this reason, we undertook cloning of viral DNA in *E. coli* within the pBR322 plasmid. In this article, we submit evidence of the structure of cloned DNA and its tentative physical map.

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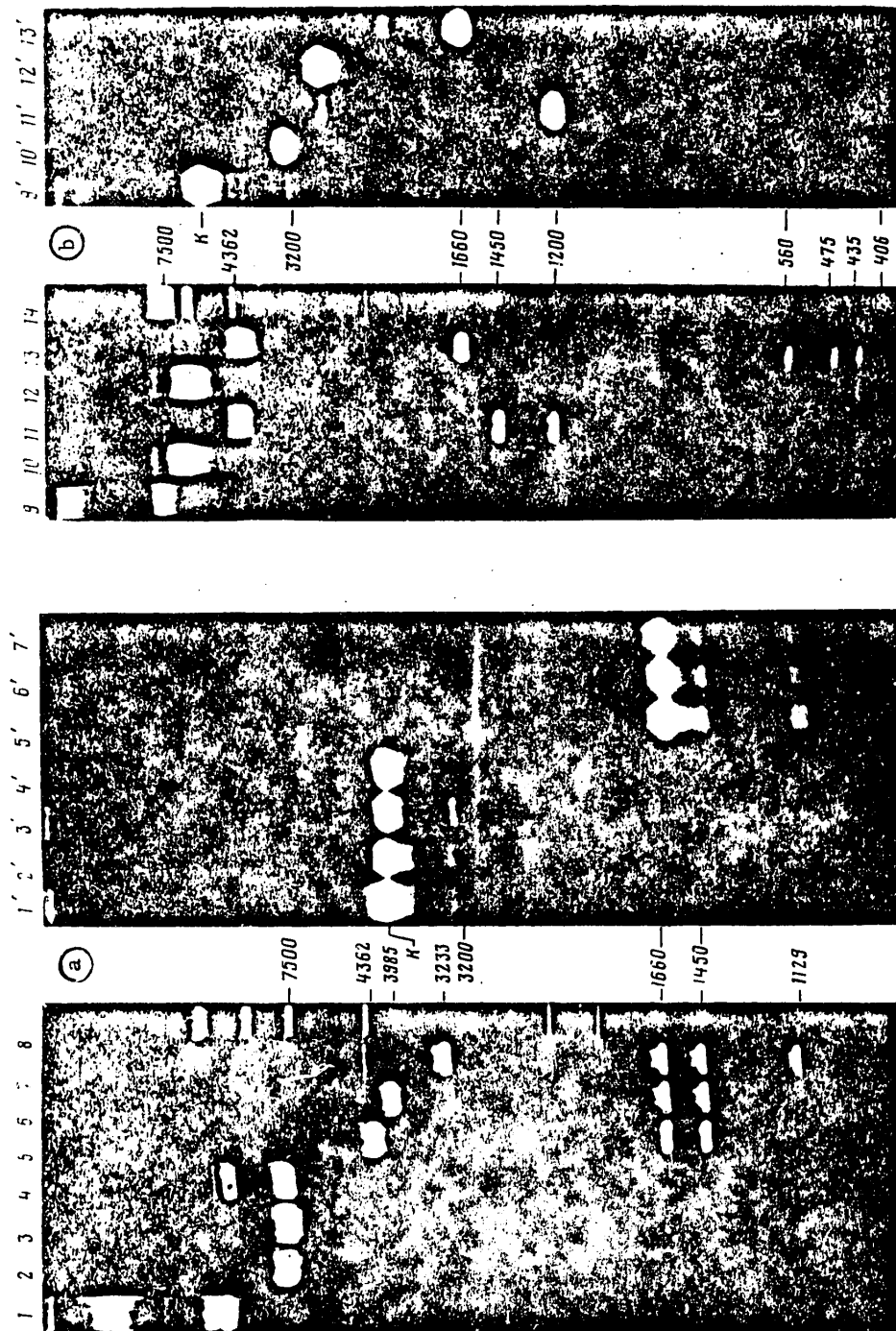


Figure 1. Electrophoretic separation in 1% (a) and 1.4% (b) agarose gel of plasmid pHB320 DNA fragments: ethidium bromide stain (1-14) and 32 P-DNA of hepatitis virus B--autoradiogram (1'-13') after separation with restriction enzymes. Fragment sizes in pairs of bases.

Lane	Enzymes	Fragment Sizes (bp)
1,1'	EcoRI	13,13'
2,2'	EcoRI	10,10'
3,3'	HindIII	11,11'
4,4'	PstI	11,11'
5,5'	BamHI	12,12'
6,6'	BamHI + EcoRI	10,10'
7,7'	BamHI + PstI	11,11'
8,8'	DNA of λ phage + HindIII	12,12'
9,9'	BamHI + EcoRI	10,10'
10,10'	XhoI	13,13'
11,11'	XhoI + BamHI	13,13'
12,12'	BglII	13,13'
13,13'	BglII + BamHI	13,13'
14,14'	B DNA	13,13'

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Viral particles were isolated from the blood plasma of donors, which was positive for HB_sAg and endogenous DNA polymerase activity. The obtained viral preparations were tested with electron microscopy. The single-stranded DNA segment was built up by means of endogenous DNA-polymerase reaction in the presence of three unlabeled dNTP and α -³²P-dATP; isolation of DNA and purification thereof were performed by known methods [3]. Preliminary restriction analysis of viral DNA revealed that it is wanting in the sites of HindIII, PstI and EcoRI restrictases. The latter had been demonstrated in all previously examined DNA of hepatitis virus B and was used to clone viral DNA. We separated viral DNA with BamHI restrictase, for which two sites were demonstrated, and we ligated the obtained fragments with DNA of plasmid pBR322 after separating the latter with BamHI and treating it with alkaline phosphatase, using DNA ligase of T4 phage. After transformation of *E. coli* RRI cells, clones were selected with the Ap^rTc^s phenotype, while electrophoretic analysis of plasmid DNA of these clones in agarose gel, both without dissociation and after segregation of BamHI, enabled us to select clones with plasmids having insertions for the BamHI site, and their dimensions correspond to BamHI fragments of the initial viral DNA. One of the plasmids, pHB320, had an insertion of two BamHI fragments, and both were hybridized with ³²P-labeled DNA of hepatitis virus B.

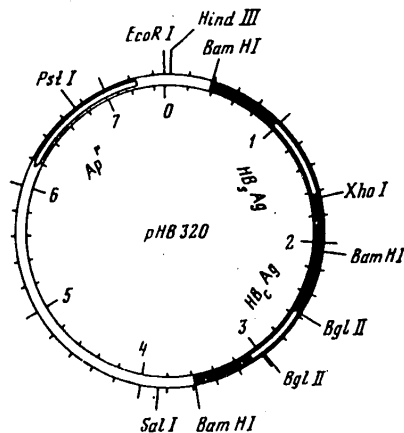


Figure 2.

Physical map of pHB320 plasmid (1000 pairs of bases)

made it possible to unequivocally determine the orientation of the splice in the plasmid (Figure 2).

The DNA of hepatitis virus B that we cloned demonstrates a greater resemblance to the DNA of virus of subtype ayw [12], rather than adw₂ [13], which is manifested, first of all, by the relative location of BamHI, BglII and XhoI sites. The latter is absent in adw₂ DNA. The following are absent in the DNA we cloned: EcoRI site, which is typical for both subtypes of viral DNA, as well as one of the sites for BamHI and BglII of those present in ayw DNA. A comparison of the physical maps of pHB320 DNA and DNA of subtype ayw virus [12] indicates that the fragments cloned in the BamHI plasmid have the same reciprocal orientation as in the initial viral DNA.

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Separation of pHB320 DNA by BspI and HindII restrictases yields a set of new fragments, which present virtually total resemblance to the DNA we cloned with DNA of subtype ayw virus. Combined segregation by these restrictases with BamHI confirms the orientation of the insert illustrated in Figure 2.

Thus, we succeeded in cloning DNA of hepatitis virus B that is the most widespread in Latvia, since the physical maps of the cloned DNA and major component of DNA of virus isolated from a combined ["overall"] blood plasma preparation were identical, and this was found in two independent experiments. Unlike the most popular procedure for cloning DNA of hepatitis virus B using the EcoRI site, we cloned viral DNA for one of the two BamHI sites, namely, the one located in the single-stranded segment of DNA [12]. This may be of decisive significance for expression of HBsAg in homologous systems, since the region preceding HBsAg remains untouched with such cloning.

The authors are sincerely grateful to Yu. A. Ozol for preparing the strongly labeled α -³²P-dATP, as well as to V. P. Ose for electron microscopic analysis, N. V. Pudova, Ya. V. Kalis and I. D. Kholodnyuk for their assistance in different experiments, A. A. Yanulaytis and R. P. Martsishauskas for DNA ligase of T4 phage and restrictase of EcoRI, HindII, HindIII, BspI, PstI, BamHI, V. I. Tanyashin for supplying XhoI restrictase and N. M. Pustoshilova for furnishing BglII restrictase.

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ROLE OF FEEDING IN REPRODUCTION OF RODENT FLEAS (SIPHONAPTERA) AS RELATED TO DIFFERENT HOSTS

Leningrad ENTOMOLOGICHESKOYE OBOZRENIYE in Russian Vol 60, No 3, Jul-Sep 81 pp 562-568

[Article by I. V. Chumakova, M. P. Kozlov and A. M. Belokopytova, Plague Control Scientific Research Institute of Caucasus and Transcaucasia, Stavropol']

[Text] In spite of the fact that there is distinct reference to a specific host or narrow group of hosts of most species of fleas, i.e., being specific, the majority of flea species can breed on various warm-blood animals and even reptiles, without demonstrating narrow specialization (Darskaya, Besedina, 1961; Bryukhanova, 1961; Vashchenok et al., 1976, and others).

Ioff (1941), who attributed special importance to the specificity of flea feeding, stressed that the question of their preference for a specific animal species has not been sufficiently settled. In the opinion of that author, specificity could be due to the structural distinctions of the piercing part and length of proboscis, which enables them to pierce skin of a specific thickness, structure of sense organs and purely external ecological conditions.

At the same time, it was shown (Hudson and Prince, 1968) that differences in fertility are also demonstrable when fleas suck blood from representatives of different groups of warm-blooded animals. The yield of *Pulex irritans* imagos per female can vary by tens of times (8.0 imagos per female per day when feeding on man, 1.2 when feeding on the guinea pig and 0.4 on the dog). Haas (1965) mentions the difference in number of offspring that could be obtained from fleas of the same species that fed on different hosts. Differences have been established between reproduction of *Xenopsylla cheopis* and *Ceratophyllus fasciatus* fleas when they fed on the golden hamster, white rat and white mouse (Samarina et al., 1968). Fertility was found to be higher when feeding on the golden hamster than other hosts. In addition, Alekseyev (1961) demonstrated that *Ceratophyllus consimilis* fleas feeding on the ratlike hamster not only deposited more eggs than when they fed on the white rat and white mouse, but that maturation and oviposition occurred sooner.

Numerous field observations also revealed that exchange of fleas between different rodent species in their natural habitat is a common phenomenon, particularly in areas where there are mixed settlements thereof. It must be assumed that these distinctions of correlations between parasite and host have a significant influence on the geographic distribution of fleas, formation of populations, as well

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as quantity thereof. Herein lies the special theoretical and practical importance of studying whether different flea species can possibly survive and reproduce for a long period of time on hosts that are not inherent to them. The need for such studies is attributable to the link between this problem and such questions as laboratory cultivation and evaluation of the role of fleas as carriers of fleas in epizootiology and epidemiology.

We submit here the results of comparative observation of reproduction of three species of fleas as related to feeding on their main host and hosts that are not inherent to them.

Material and Methods

We used 5-day-old fleas, which had not eaten after coming out of the cocoon (*Xenopsylla conformis* Wagn., *Ceratophyllus laeviceps* Wagn., *C. tesquorum* Wagn.), from laboratory populations maintained constantly on their main hosts (midday gerbil for the first two species and little suslik). The reproductive distinctions of these fleas were studied on the midday gerbil, little suslik, common vole, golden hamster, white rat, white mouse, guinea pig, rabbit and house sparrow. The fleas were kept in rectangular glass containers (chamber-jars), on the bottom of which we spread dry, baked sand with addition of feed for larvae. We placed 2-3 sheets of filter paper on the sand to absorb urine of the host, and the cage with an animal was placed on the paper. There was prevalence of dry feed in the animals' diet. The fleas were placed on each host in quantities of 60 specimens on each (45 females and 15 males). The chamber-jars with animals and fleas were then constantly kept in temperature-controlled boxes ["termoboks"?] where the temperature was automatically held at 24° and humidity at 75-80%. We took a daily count of surviving males and females and moved them to a new substrate. The substrate with deposited eggs was kept under the same conditions until imago hatched. We kept a record of average offspring per female according to imago yield. We observed flea fertility for 15-30 days. The experiments were repeated 3-4 times in each season.

In order to examine feeding activity on different hosts, 5-day-old fleas, which had not eaten after hatching from the cocoon, were weighed, at the rate of 200 per field, on a balance, and groups of 50 fleas were put on the animal. The insects were combed off the animal after 20, 30, 40 and 60 min; the percentage of feeding insects was recorded, and determination made of the weight of blood consumed within a specific time spent on the host.

The data were submitted to statistical processing according to Kaminskiy (1964).

Results and Discussion

The results of this study indicate that the weight of blood ingested by female and male fleas is equally independent of the species-specific distinctions of the host, and in our experiments it ranged from 0.04 to 0.06 mg in female *X. conformis*, 0.03 to 0.04 mg in male *X. conformis*; in *C. tesquorum* it ranged from 0.13 to 0.25 mg for females and 0.06 to 0.11 mg for males (Table 1).

The time that the insects spent on the host also failed to affect the weight of blood consumed by one flea. Within the first 20 min, the fleas had ingested as much blood as specimens that spent 1 h on the animal (Table 2).

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Table 1. Weight of blood consumed by fleas when feeding on different hosts

Flea species	Host animal species	Blood (mg) consumed by each flea			
		females		males	
		quantity of fleas	blood wt., M±m	quantity of fleas	blood wt., M±m
<i>Xenopsylla conformis</i> Wagn.	Midday gerbil	438	0.05±0.01	116	0.04±0.01
	Guinea pig	400	0.04±0.01	239	0.03±0.008
	Rabbit	200	0.08±0.01	200	0.0 ±0.009
	Little suslik	156	0.05±0.01	139	0.04±0.01
	Golden hamster	394	0.06±0.01	200	0.03±0.01
	White mouse	303	0.05±0.01	392	0.04±0.007
	White rat	313	0.07±0.01	150	0.03±0.006
	Common vole	211	0.05±0.01	200	0.03±0.01
<i>Ceratophyllus tesquorum</i> Wagn.	Little suslik	286	0.13±0.02	149	0.06±0.01
	Guinea pig	100	0.17±0.01	191	0.08±0.03
	Golden hamster	200	0.13±0.009	192	0.10±0.01
	Midday gerbil	100	0.16±0.06	102	0.09±0.03
	White mouse	247	0.17±0.03	346	0.11±0.01
	White rat	189	0.25±0.05	200	0.10±0.01
	House sparrow	13	0.19±0.01	9	0.14±0.01

Table 2. Weight of blood consumed by fleas as a function of time spent on host

Time spent on host, min	<i>Xenopsylla conformis</i> Wagn.				<i>Ceratophyllus tesquorum</i> Wagn.			
	females		males		females		males	
	quantity of fleas	blood weight, mg, M±m	quantity of fleas	blood weight, mg, M±m	quantity of fleas	blood weight, mg, M±m	quantity of fleas	blood weight, mg, M±m
20	490	0.04±0.01	400	0.03±0.01	340	0.16±0.01	385	0.05±0.01
30	586	0.06±0.01	425	0.05±0.01	371	0.21±0.04	328	0.11±0.01
40	586	0.06±0.01	405	0.05±0.01	512	0.14±0.02	390	0.08±0.02
60	634	0.06±0.01	396	0.04±0.01	383	0.14±0.02	383	0.11±0.03

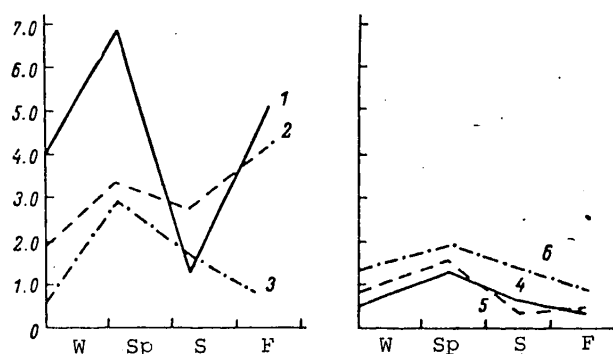
At the same time, there was a reliable difference in feeding activity of fleas on different species of hosts. Thus, *C. tesquorum* ingested blood actively on different host species and most specimens were satiated already within 30-40 min. The imagos of this species ingested blood faster and in larger amounts on a specific host. The lowest percentage of fleas that were satiated within both 20 min and 1 h was found on the midday gerbil and golden hamster (Table 3). In contrast, the role of the main host--midday gerbil--in feeding activity was not demonstrable in *X. conformis*. The percentage of fleas that fed on the gerbil for the first 20 min and thereafter did not exceed the percentage of fleas feeding on other hosts. The highest percentage of feeding imagos was established among females on the white rat (64.0), rabbit (65.0) and common vole (77.0). The percentage of feeding *X. conformis* fleas left on other hosts for 1 h was in the range of 22.0-44.0. The number of fleas that sucked blood increased with increase in time left on the animals. But, even after being on a host for 1 h, there was a high

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percentage of fleas that had not yet been satiated in virtually all groups, both among males and females (33.0-77.7% for females and 62.5-75.0% for males). According to the percentage of feeding specimens, females of both flea species fed more actively after hatching from the cocoon than males.

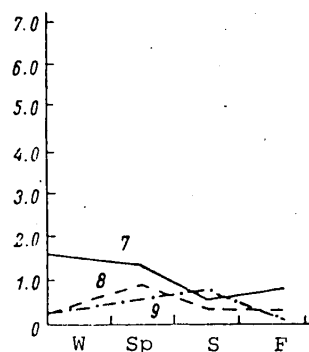
Analysis of flea fertility revealed that *X. conformis* and *C. laeviceps* reproduce better when kept on their main host and the golden hamster, whereas the golden hamster and white mouse are the best hosts for the *C. tesquorum* suslik fleas. The mean duration of development from the time of birth of larvae to hatching of imagos was 4-5 days shorter when maintained on a nonspecific host, the golden hamster, than on a specific host. *C. tesquorum* fleas reproduced worse on the little suslik under laboratory conditions than on such nonspecific hosts as the golden hamster and white mouse. Both gerbil and suslik fleas reproduced poorly on some species of animals (guinea pig, house sparrow) (Table 4). It is remarkable that there is a distinct seasonal pattern to reproduction, in spite of the fact that the fleas were maintained at a stable temperature and humidity throughout the year. Thus, an increase in fertility of *X. conformis* was observed in the spring on all host species. Fertility diminished in the summer and fall months, and increased in the fall only when kept on their main host and golden hamster (see Figure).



Reproduction of *Xenopsylla conformis* Wagn. in different seasons on different hosts. Y-axis, quantity of imagos per female per day.

- 1) gerbil
- 2) golden hamster
- 3) white mouse
- 4) little suslik
- 5) white rat
- 6) common vole
- 7) rabbit
- 8) guinea pig
- 9) house sparrow

W) winter
Sp) spring
S) summer
F) fall



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Our findings indicate that, regardless of morphological distinctions of the piercing organ, as well as thickness of hosts' skin, different flea species ingest the same amount of blood on both specific and nonspecific hosts.

Table 4. Flea reproduction when feeding on different species of hosts

Host	<i>Ceratophyllus tesquorum</i> Wagn.		<i>Xenopsylla conformis</i> Wagn.		<i>Ceratophyllus laeviceps</i> Wagn.	
	female- days	imago yield/ female/ day	fem.- days	imago yield/ female/ day	fem.- days	imago yield/ female/ day
Rabbit	607	1.0	658	2.7	239	1.1
Little suslik	1214	1.5	1111	1.4	867	1.0
Guinea pig	1081	0.7	998	0.9	907	0.9
White rat	613	1.9	868	1.5	723	1.2
White mouse	721	3.0	1256	2.3	1362	1.3
Golden hamster	1877	5.7	1526	5.3	1225	6.8
Midday gerbil	1253	0.9	1181	7.0	986	1.4
Common vole	1404	2.1	1001	2.4	951	1.4
House sparrow	1029	0.9	1147	0.7	512	0.4

Table 5. Life span of *Ceratophyllus laeviceps* Wagn. fleas on different hosts

Day of study	Percentage of surviving fleas											
	gerbil		suslik		hamster		mouse		rat		guinea pig	
	quantity of fleas in experiment											
	females 60	males 20	females 60	males 20	females 60	males 20	females 60	males 20	females 60	males 20	females 60	males 20
2-3	100	95.0	98.0	100	100	100	100	65.0	75.0	75.0	100	75.0
4-7	91.0	90.0	98.0	85.0	100	90.0	90.0	45.0	41.0	50.0	83.0	50.0
8-10	83.3	90.0	91.6	85.0	90.0	65.0	90.0	40.0	28.3	35.0	58.3	35.0
11-14	66.6	25.0	78.3	50.0	90.0	65.0	65.0	20.0	28.3	20.0	48.3	15.0
15-18	66.6	0.0	66.6	50.0	66.6	50.0	41.6	20.0	11.6	5.0	36.6	15.0
19-22	66.6	—	65.0	45.0	60.0	15.0	41.6	20.0	11.6	5.0	36.6	15.0
23-26	43.3	—	30.0	10.0	60.0	15.0	28.3	10.0	6.6	5.0	36.6	15.0
27-30	15.0	—	23.3	5.0	55.0	0.0	28.3	10.0	3.3	0.0	33.3	15.0
31-34	11.6	—	21.6	5.0	21.6	—	28.3	10.0	3.3	—	28.3	10.0
35-39	8.3	—	6.6	0.0	10.0	—	16.6	10.0	0.0	—	25.0	0.0
40-44	3.3	—	0.0	—	8.6	—	11.6	10.0	—	—	15.0	—
45-47	0.0	—	—	—	8.3	—	10.0	10.0	—	—	15.0	—
48-52	—	—	—	—	5.0	—	8.3	10.0	—	—	13.3	—

The life span of fleas was found to vary on nonspecific hosts. We failed to demonstrate signs of host specialization in *C. laeviceps*. Death occurred more slowly when on the golden hamster, white mouse and guinea pig than on the gerbil (Table 5).

We also failed to demonstrate a significant effect of upkeep conditions on the offspring. Thus, the weight of the initial population of *C. laeviceps* at the age of 5 days constituted 0.35 ± 0.01 mg for females and 0.27 ± 0.02 mg for males. First

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generation offspring presented the following weight on different hosts: 0.37 ± 0.01 and 0.27 ± 0.01 , respectively, on the midday gerbil; 0.35 ± 0.02 and 0.26 ± 0.02 on the golden hamster; 0.33 ± 0.01 and 0.26 ± 0.02 on the little suslik; 0.37 ± 0.04 and 0.25 ± 0.01 on the white mouse; 0.33 ± 0.01 and 0.26 ± 0.02 on the common vole.

Thus, there is reason to assume that it is not so much structural distinctions as physiology and ecological conditions that are significant to feeding and, consequently, distinctions of reproduction of fleas when placed on different animal species. The different species of fleas ingest and assimilate blood from nonspecific animals and, under optimum upkeep conditions, can reproduce on them the year round. Only differences in fertility are demonstrable as a function of host and time of year.

Vashchenok et al. (1976) demonstrated, on the example of *X. cheopis*, that fleas ingest and assimilate the blood of different species of rodents, birds, man and reptiles; but there are substantial differences in the digestive process. Blood digesting time is different for different hosts. Digestion of human and golden hamster blood to hematin takes place in 12-20 h; for blood of the guinea pig and reptiles the time is 18-25 h, for the white rat and pigeon it is 20-30 h. There is slower breakdown of bird and reptile erythrocytes than rodent erythrocytes. This cannot fail to affect reproduction, if we consider that the first intake of food is the stimulus for development of oocytes up to fertilization in females (Vashchenok, 1967). This apparently also explains the reproductive distinctions of fleas feeding on various hosts. Samarina et al. (1968) assumes that the observed differences in fertility are attributable to different sets of amino acids contained in host blood. But this hypothesis has not yet been verified. Nor can we rule out the possibility of dependence of flea fertility on presence of hormones. Rothschild and Ford (1964) demonstrated that host corticoid hormones are required for reproduction of the rabbit's flea (*Spilopsyllus cuniculi* Dall), since the ovaries do not mature without them. Such a dependence was demonstrated, though in a less marked form, in experiments with *Xenopsylla astia* Rothschild. (Prasad, 1973).

In conclusion, it should be stressed that, on the basis of our findings and data in the literature, one could refer to relative feeding specialization in such species of fleas as *C. tesquorum*, *C. laeviceps* and *X. conformis*, in spite of their rather high specificity. They have greater potential capacity to survive in mixed rodent populations, since they can feed and reproduce on hosts that are not inherent in them, which inhabit the same ecological conditions. On this basis, one should be cautious in making conclusions about indicators of contact between different rodent species solely on the basis of incidence of fleas on noninherent hosts. These data may also serve as an indirect indication that when eradicating the main carrier, as the above-mentioned species of fleas, which are the main vectors of plague in a number of endemic sites, move to other species of animals susceptible to plague, they may not only survive, but participate for some time in maintaining the epizootic process.

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IMMUNOTHERAPY OF INFECTIOUS-ALLERGIC BRONCHIAL ASTHMA BY AEROSOLS CONTAINING BACTERIAL ALLERGENS

Moscow IMMUNOLOGIYA in Russian No 6, Nov-Dec 81 (manuscript received 25 Nov 80) pp 63-67

[Article by V. S. Moshkevich, Scientific Research Institute of Epidemiology, Microbiology and Infectious Diseases, Kazakh SSR MInistry of Health Alma Ata]

[Text] Hospital records show that an average of 2.7 out of every 1,000 inhabitants of our country are admitted to our country's hospitals for treatment of bronchial asthma. Major surveys, however, have revealed that morbidity is actually even higher--7.8 per 1,000 inhabitants (1). The infectious-allergic form is the most severe manifestation of the disease.

Bacterial allergens have been enjoying extensive use in the treatment of this pathology in recent years. A positive impact has been gained from specific hyposensitization in an average of 45 percent of patients with the infectious-allergic form of bronchial asthma (2,11,14,15,19,21,23,25). Subcutaneous and intracutaneous injection of bacterial allergens is presently the commonly accepted method of immunotherapy for bronchial asthma. However, various complications, which are encountered in 8-20 percent of the cases and which reduce the method's effectiveness, prevent broad application of this useful method (3,7,12,24).

It is for these reasons that attempts are being made to improve the methods of hyposensitization. Attempts have been made in specific treatment of hay fever by application of pollen antigens to respiratory mucosa (18,22). This method has now achieved widespread acceptance, since it has a number of advantages over the injection method of treating hay fever (8). Use of bacterial allergen aerosols is a further development of local specific hyposensitization in the presence of bronchial asthma.

Research Methods

Infectious-allergic bronchial asthma was definitely diagnosed in 190 patients in the allergological ward of the Republic Clinical Hospital. The specific diagnoses were made in 1975-1979 by methods commonly accepted in clinical allergology: allergological anamnesis, skin and provocative tests, immunological tests *in vitro* and so on (10). This group of patients was dominated by women (61 percent), persons 21-40 years old (65 percent), white collar workers (46 percent) and residents of the northern oblasts of the Kazakh SSR (42 percent). An illness duration of 5-10 years was established

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for 52 percent of the patients. Mild attacks of labored breathing on the background of aggravated infection foci without chronic pulmonary insufficiency (II₁ using the classification suggested by A. D. Ado and P. K. Bulatov) were encountered among 59 percent of the patients. Chronic infectious-allergic rhinitis (38 percent) and chronic bronchitis (13 percent) were noted as accompanying diseases. The results of specific treatment of 112 patients with the infectious-allergic form of bronchial asthma by the commonly accepted injection method served as the control. These patients were treated in our clinic earlier (1970-1974).

AI-1 (USSR) and TUR YuSI-51 (GDR) series-produced inhalers were used to introduce the bacterial allergens into the respiratory tract. The treatment consisted of courses with an interval of 1 year. Fifty-two percent of the patients underwent one course of treatment, 27 percent underwent two and 21 percent underwent three and more. A therapeutic complex containing those allergens in relation to which heightened sensitivity was revealed was prepared for the immunotherapy. Forty percent of the patients received one antigen, 42 percent received two and 18 percent received three and more. The therapeutic complexes administered to 38 percent of the patients contained different strains of *Staphylococcus*, 32 percent received *Streptococcus*, 26 percent received *E. coli*, 20 percent received *Neisseria*, 13 percent received *Proteus*, 10 percent received *Pneumococcus* and 3 percent received other bacteria. Bacterial therapeutic antigens were employed (provided by the Kazan' Scientific Research Institute of Epidemiology and Microbiology): from apathogenic *Staphylococcus aureus*, hemolytic *Staphylococcus*, group pneumococcal allergen, hemolytic *Streptococcus*, *Proteus mirabilis*, *E. coli*, *Bacillus pyocyaneus*, *Neisseria*, etc. These antigens have been available in the pharmaceutical network for many years. The number of inhalations depended on the initial dose, which was determined by allergometric titration on respiratory tract mucosa (49 percent of the patients received 10-20 inhalations while 39 percent received 21-30). The treatment method was described in detail earlier (7).

Specific therapy was conducted during remission of the disease following relief of the aggravated state and clearing of infection foci. During hyposensitization with bacterial allergen aerosols, the patient was not subjected to other treatment methods. Treatment effectiveness was evaluated on the basis of special questionnaires containing 15 questions, which the patient answered during his follow-up examination. The catamnesis was recorded in a period from 3 to 30 months, the average being after 12.6 months. The treatment results were evaluated by a five-point system. A score of 1 meant subjective and objective worsening of state following treatment, or that treatment was interrupted due to aggravation of the illness; 2 meant no change; 3 meant a decrease in the frequency and intensity of attacks of labored breathing; 4 meant rare and mild attacks of labored breathing that were easily curtailed by drugs without referral to a physician; 5 meant absence of attacks and complaints.

Results and Discussion

The effectiveness of therapy using bacterial allergen aerosols was found to be significantly higher than that of the commonly accepted classical method of subcutaneous immunotherapy (Table 1). The time of remission following immunotherapy was up to 1 month for 16 percent of the patients, up to 3 months for 18 percent, up to 6 months for 22 percent, up to 1 year for 18 percent and up to 2 years for 26 percent; it averaged 8.3 months.

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Analysis of aggravations of bronchial asthma and complications accompanying specific therapy showed that aerosol therapy is accompanied by significantly fewer pathological reactions in comparison with the commonly accepted injection method (Table 2).

Table 1. Effectiveness of the First Course of Treatment With Bacterial Allergens (Quantity of Patients, %)

Treatment Method	Score in Points					Average Score
	5	4	3	2	1	
Inhalation	33	32	17	13	5	3.75
Injection	18	28	24	19	11	3.23

Table 2. Complications Accompanying Immunotherapy (Quantity of Patients, %)

Treatment Method	No Reactions	Mild Reactions		General and Severe Reactions	Treatment Curtailed Due to Aggravation
		Few	Many		
Inhalation	64	18	12	2	4
Injection	60	13	10	10	7

Table 3. Change in Skin Allergic Tests Following Aerosol Therapy With Bacterial Allergens (Quantity of Patients, %)

Period of Examination	Specific Antigen					Nonspecific Antigen				
	Skin Test Score					Skin Test Score				
	-	+	++	+++	++++	-	+	++	+++	++++
Before treatment	-	1	7	45	47	21	4	15	41	19
After treatment	26	16	21	24	13	26	5	19	34	16

Skin allergic tests were performed before and after treatment with several bacterial allergens; thus we were able to observe the decrease in sensitivity in relation to both specific antigens (used in the therapy) and nonspecific antigens (not used in the therapy of the given patient). We found that following treatment with bacterial allergen aerosols, highly positive and positive skin tests with allergens used in the therapy (specific) decreased five times more frequently than in relation to nonspecific allergens (Table 3).

The neutrophil damage indicator (NDI) is an objective indicator of the body's sensitization to bacterial allergens. It reflects the dynamics of sensitization in the bodies of patients with respiratory allergosis undergoing treatment with bacterial antigens (6,16). Analysis of the results (Table 4) showed that following aerosol

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therapy the NDI became normal in 21 percent of patients with infectious-allergic bronchial asthma, while following the injection method of treatment the NDI became normal in 32 percent of the patients. The number of patients with a dramatically enlarged NDI following treatment by the injection method decreased by 22 percent, while for patients receiving aerosol therapy the figure was only 7 percent.

Table 4. Changes in NDI of Patients With Bronchial Asthma (Quantity of Patients, %)

Time of Examination	Method of Treatment	Degree of Change in NDI			
		Normal	Slight Increase	Increase	Large Increase
Before treatment	Aerosol	32	43	17	8
	Injection	38	15	24	28
After treatment	Aerosol	53	36	10	1
	Injection	70	21	8	1

Sensitivity of the bronchi to bacterial allergens following specific treatment, as determined by a provocative test, is an important indicator of the effectiveness of aerosol therapy in patients with bronchial asthma. We studied the dynamics of the sensitivity of bronchi to both specific and nonspecific antigen. The frequency of sensitivity to specific bacterial allergens (a positive provocative test) decreased from 100 percent (prior to treatment) to 55 percent (after treatment)--that is, in 45 percent of the patients. To analyze the decline in sensitivity to non-specific antigens, we used the same allergens from the Kazan' Scientific Research Institute of Epidemiology and Microbiology which we used in our research on specific reactions. The frequency of sensitivity in relation to nonspecific antigen decreased from 48 to 39 percent--that is, in only 9 percent of the patients. According to data from allergometric titration, the threshold of sensitivity of the bronchi of most patients (76 percent) prior to treatment was within 10^{-8} and 10^{-5} allergen dilutions, the average being 6.3 ± 0.1 . Following treatment it increased for most patients (71 percent) to 10^{-4} - 10^{-2} allergen dilutions, the average being 3.7 ± 0.1 . Thus following treatment with aerosols containing bacterial allergens the sensitivity of bronchi to specific antigen decreased by an average of three orders of magnitude, while their sensitivity to nonspecific antigen decreased by an average of one order of magnitude.

Hypergammaglobulinemia associated with antibody formation is observed in the presence of allergic diseases. Therefore we studied the protein fractions of blood serum from patients with bronchial asthma before and after aerosol therapy using bacterial allergens (Table 5). Prior to treatment the total quantity of protein and albumins and the albumin-globulin coefficient (A/G) were low. Following specific therapy we did not reveal significant changes in the proteinogram of peripheral blood; nor did the sedimentation rate change.

Blood lymphocytes and eosinophils play an important role in the development of allergic inflammation and in the mechanisms of specific therapy. Introduction of bacterial allergens into patients suffering infectious allergy is accompanied by change in the white blood formula (5). The peripheral blood of bronchial asthma

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patients was characterized prior to treatment by leukocytosis in 24 percent of the patients, eosinophilia in 32 percent and lymphocytosis in 12 percent. The remaining formed blood elements were within normal. Following immunotherapy using bacterial allergens, a decrease in the quantity of leukocytes and fluctuations in the quantities of eosinophils and lymphocytes were noted (Table 6).

In this case the direction and magnitude of changes in lymphocytes and eosinophils in response to inhalational and injection therapy differed. With the inhalation method the quantity of eosinophils in peripheral blood increased while the quantity of lymphocytes decreased. With the injection method, the changes in response to introduction of the allergens were opposite.

Table 5. Proteinogram of Bronchial Asthma Patients (M±m)

(1) Период обследования	(2) Общее количество белка, мг%	(3) А/Г	(4) Альбумины, %	(5) Глобулины, %				СОЭ (6)
				α ₁	α ₂	β	γ	
До лечения (7)	М 6,7 m 0,08	1,2 0,02	54,8 0,7	4,3 0,2	8,3 0,2	1,9 0,3	21,1 0,6	12,8 1,0
После аэрозоль-терапии (8)	М 6,8 m 0,1	1,2 0,001	54,5 0,6	4,5 0,2	8,5 0,2	1,7 0,3	20,8 0,5	13,0 1,1

Key:

- | | |
|------------------------|--------------------------|
| 1. Time of examination | 5. Globulins, % |
| 2. Total protein, mg-% | 6. Sedimentation rate |
| 3. A/G | 7. Before treatment |
| 4. Albumins, % | 8. After aerosol therapy |

Table 6. Dynamics of Peripheral Blood Cells Following Immunotherapy

(1) Метод лечения	(2) Период обследования	(3) Лейкоциты		(4) Лимфоциты		(5) Эозинофилы	
		I	II	I	II	I	II
Инъекции (1)	До лечения (7)	26	6240±300	10	23,7±0,7	18	5,24±0,6
	После лечения (8)	8	5780±213	16	25,5±0,7	8	4,8±0,6
Ингаляции (9)	До лечения	30	6040±253	12	27,4±0,9	12	4,26±0,4
	После лечения	22	5980±229	8	24,7±0,8	28	5,84±0,5

Note: I--quantity of patients (%) with an enlarged concentration of blood cells, II--average blood quantity (M±m).

Key:

- | | |
|------------------------|---------------------|
| 1. Treatment method | 6. Injection |
| 2. Time of examination | 7. Before treatment |
| 3. Leukocytes | 8. After treatment |
| 4. Lymphocytes | 9. Inhalation |
| 5. Eosinophils | |

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Table 7. Indicators of External Respiration (Averages)

<u>Time of Observation</u>	<u>PTM, Liters/Sec</u>	<u>LVC,%</u>	<u>MLV,%</u>	<u>FLVC, Liters</u>	<u>TC,%</u>
Before treatment	2.9	73	76	2.6	65
After aerosol therapy with allergens	3.0	75	79	2.7	67

The principal symptom of bronchial asthma is bronchospasm, which can be objectively recorded by spirometry. The most informative indicators of external respiration are lung vital capacity (LVC), which is expressed as a percentage of normal LVC, the 1-second forced lung vital capacity--FLVC (in liters), the ratio between FLVC and LVC (percent) or the Tiffno coefficient (TC), the exhalation force determined by pneumotachometry (PTM) (liters/sec) and maximum lung ventilation--MLV (percent). We studied the dynamics of external respiration in bronchial asthma patients before and after treatment with bacterial allergen aerosols. Following treatment with bacterial antigen aerosols, positive changes indicating a tendency toward normalization of bronchial passability were noted. However, the difference was physically insignificant (Table 7).

Glucocorticoid insufficiency is a foundation for development of allergic diseases (13). The total quantity of corticosteroids and the products of their metabolism in urine--17-ketosteroids (17-KS)--is an objective indicator of the state of the adrenal cortex. Prior to treatment the concentration of 17-KS in daily urine of our patients was 10.77 ± 0.95 mg, or somewhat below normal. Following treatment with bacterial allergen aerosols their quantity decreased to 8.25 ± 0.62 mg.

The reaction of specific completed phagocytosis described by Berman et al. (4) reflects the dynamics of specific immunity in patients with bronchial asthma. We studied the phagocytic activity of leukocytes--PAL (percent), the number of phagocytosed microbial bodies per active neutrophil--the digestion index (DI), the percent completed phagocytosis (PCP) and the percent neutrophils in which all microbial cells are killed using smears taken before and after specific treatment with bacterial allergens. We established that following treatment with bacterial antigens, patients exhibit higher specific immunity to *Streptococcus*; in this case immunity was significantly greater following aerosol therapy (Table 8).

We studied conditionally pathogenic flora vegetating in respiratory tract mucosa of bronchial asthma patients. Prior to immunotherapy with bacterial allergen aerosols various strains of *Staphylococcus* were cultured in samples from 35 percent of the patients, *Proteus* strains were detected in samples from 1 percent, *Streptococcus* strains were detected in samples from 3 percent and *E. coli* strains were determined in samples from 50 percent of the patients. Following treatment these indicators hardly changed at all, being 32, 2, 6 and 1 percent respectively (their differences are statistically insignificant).

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Table 8. Changes in Specific Completed Phagocytosis Following Treatment With Aerosols Containing Bacterial Antigens (Averages)

<u>Time of Examination</u>	<u>Treatment Method</u>	<u>Phagocytosis Indicators</u>			
		<u>PAL</u>	<u>PI</u>	<u>DI</u>	<u>PCP</u>
Before treatment		78	9.7	5.6	44
After treatment	Injection	82	10.2	6.8	57
	Inhalation	89	10.9	8.1	63

Table 9. Change in Sensitivity of Skin and Mucosa to Biologically Active Amines Following Immunotherapy (M±m)

<u>Time of Examination</u>	<u>Size of Dermal Papule, mm</u>				<u>Mucosa's Histamine Sensitivity Threshold</u>
	<u>Control (Physiological) Solution</u>	<u>Serotonin</u>	<u>Acetylcholine</u>	<u>Histamine</u>	
Before treatment	7.1±0.1	11.3±0.4	15.3±0.3	18.0±0.4	10 ^{-3.4}
After aerosol therapy	7.6±0.3	10.6±0.2	14.4±0.4	18.4±0.4	10 ^{-3.2}

The concentration of histamine, acetylcholine and serotonin in blood hardly changes at all during immunotherapy using injections of bacterial allergens (9). Therefore we studied the sensitivity of the skin and respiratory mucosa to histamine, acetylcholine and serotonin following immunotherapy using aerosols containing bacterial allergens. Skin sensitivity was determined from the size of papules arising 15 minutes after intracutaneous injection of 0.1 ml mediator solution at a 1:1,000 dilution. The threshold dose on the mucosa was determined by titration. As we can see from Table 9, sensitivity of the skin and respiratory mucosa following treatment with bacterial allergen aerosols hardly changed at all. The slight decline in sensitivity was found to be statistically insignificant.

Immunotherapy using bacterial allergen aerosols is more effective and less reactive than the commonly accepted method of subcutaneous injection of bacterial antigens in relation to patients with the infectious-allergic form of bronchial asthma. The time of remission following treatment is an average of 9 months, indicating that the course of therapy must be repeated in 1 year. A clinically detectable improvement in the state of patients is accompanied by a decrease in sensitivity of all body systems to specific bacterial allergens, as determined from skin allergic tests. However, the decline in sensitivity of the bronchi to an etiological allergen is more pronounced following aerosol therapy, according to provocative tests, indicating that hyposensitization is predominantly local in nature. Aerosol therapy using bacterial allergens has a positive effect on the principal symptom of bronchial asthma--bronchospasm (according to spiographic

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data). Absence of changes in the proteinogram emphasizes the local mechanism of aerosol immunotherapy. The completed phagocytosis reaction revealed an increase in specific immunity following aerosol therapy. Hyposensitization by aerosols containing bacterial antigens was found to be highly specific.

The difference between the injection and aerosol methods of immunotherapy is confirmed by different directions in the changes experienced by the quantity of cells in white blood following treatment, especially the quantity of lymphocytes. The aerosol method of immunotherapy has almost no effect on pathogenic flora in the respiratory tract. Nor were biologically active amines--histamine, serotonin and acetylcholine--found to participate in the mechanism of hyposensitization by bacterial aerosols. At the same time immunotherapy using bacterial antigens elicits slight changes in glucocorticoid metabolism.

Presence of a local defense system in the mucosa of the respiratory tract has now been established, based on secretory IgA. The mechanism behind the local influence of bacterial vaccines is now being studied. The decrease in sensitivity of the mucosa is apparently associated with blockage of microbes and viruses entering from without, with IgA and with stimulation of T-suppressors (17,20).

Conclusions

1. Use of aerosols containing bacterial allergens for specific treatment of the infectious-allergic form of bronchial asthma produced good and excellent results in 55 percent of the patients.
2. The effectiveness of local immunotherapy was greater than that of the injection method of introducing the allergens, and it was accompanied significantly less frequently by vaccine reactions and by complications on the part of various organs and systems.
3. Analysis of the tests run in this project showed that the positive effect of treatment is the product of a decline in hypersensitivity and a rise in immunity mainly of the respiratory tract mucosa--that is, hyposensitization of the organ subjected to shock occurred.

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BIONICS

GEOGRAPHIC GROUPINGS OF PELAGIC CEPHALOPODS IN TROPICAL WEST PACIFIC

Moscow TRUDY INSTITUTA OKEANOLOGII IM. P. P. SHIRSHOVA: GLUBOKOVODNYYE BIOLOGICHESKIYE ISSLEDOVANIYA V ZAPADNOY TROPICHESKOY CHASTI TIKHOGO OKEANA in Russian Vol 107, 1977 pp 7-14

[Article by K. N. Nesis from book "Works of the Institute of Oceanology imeni P. P. Shirshov: Deep-Sea Biological Studies in the Western Tropical Part of the Pacific Ocean", USSR Academy of Sciences, Izdatel'stvo "Nauka" (reprint)]

[Text] We submit here the results of processing pelagic cephalopods gathered during the 50th (April-July 1971) and 57th (February-May 1975) voyages aboard the Vityaz' [ship]. A variable depth Isaacs-Kidd trawl was the main equipment used to collect mesopelagic and bathypelagic species during both voyages; surface water species were caught with a scoop, metal lures [fish-shaped], pleustonic and neustonic trawls. Plankton and cephalopods were also caught in benthonic fishing gear when hoisted to the surface.

During the 50th voyage, work was conducted in four areas, where many days were spent, and several short-term stations to the north and south of the Caroline Islands, in the Sulu and New Guinea seas. The variable-depth trawl was used for fishing down to a depth of 500 m over divided water lines. During the 57th voyage, work was done in two meridional sections, approximately along the 127-128° and 142-144° parallel, east longitude, from the islands of Okinawa and Bonin to the equatorial region, as well as in the Sulawesi, Sulu, Flores, Banda, Seram, Halmahera and New Guinea waters and in the region of the Mariana Islands. Trawling was conducted at levels of 100, 200, 500, 1000 and 1350-1500 m. During both voyages, trawling was done at night. In all, there were 171 trawlings in 35 sites. The material provides a full enough idea about the fauna of oceanic cephalopods of the western tropical part of the Pacific Ocean, from Kuroshio to the equator and from the Philippines to 150° east longitude, Indonesian and Philippine seas. The distribution of cephalopods in the northern extratropical and eastern tropical parts of the Pacific has been described previously (Nesis, 1973a, b).

During these voyages, many cephalopod species were found, which were either new or not previously known in this region. A new genus and species of Seniolidae was found in the Halmahera Sea, which is referable to a new subfamily. New species were discovered of the genera Chiroteuthoides and Tankaia (Chiroteuthidae family) and Mastigoteuthis (Mastigoteuthidae family). For the first time since it was originally described, we found Chiroteuthis famelica Berry, 1909, which had to be put in a special genus of the Chiroteuthidae family. The following were

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found for the first time in the Pacific: *Enoploteuthis anaspis* Roper, *E. Leptura* (Leach) (new subspecies), *Octopoteuthis megaptera* (Verrill), *Octopoteuthis* n. sp. Nesis, *Brachioteuthis picta* Chun, *Cycloteuthis akimushkini* Filippova, *Chiroteuthis joubini* Voss (?), *Mastigoteuthis glaukopis* Chun, *M. atlantica* Joubin, *Egea inermis* Joubin, and for the first time in the western Pacific: *Heteroteuthis* cf. *hawaiiensis* Berry,* *Iridoteuthis iris* (Berry), *Bathyteuthis abyssicola* Hoyle, *Discoteuthis discus* Young and Roper (?), "*Chiroteuthis*" *famelica* Berry, *Valbyteuthis oligobessa* Young, *Mastigoteuthis dentata* Hoyle, as well as *Lepidoteuthis grimaldii* Joubin, which had been previously known in the southwestern part of this ocean.

The catches taken during the 50th voyage yielded 37 oceanic and nerito-oceanic species and during the 57th--75 species. All of the species but one of those caught during the 50th voyage were also represented in the catches of the 57th voyage. Thus, the collection under study numbers 76 species.

The area of our investigation is situated entirely in the tropical zone, and it is only in the extreme north, in the Kuroshio region, that species were encountered that are not inherent in the tropics--peripheral and subtropical--south boreal. The species we encountered can be divided into six zoogeographic complexes: 1) those distributed over the entire area studied--broadly tropical; 2) those distributed in the equatorial and central waters, but not encountered in the Japan Current--narrowly tropical; 3) those encountered in the equatorial and Kuroshio region, but not central waters; 4) those encountered only in the equatorial zone: a--everywhere, b--in the Indonesian and Philippine seas, but not in the open sea, c--only in the open sea; 5) distributed in central waters; 6) distributed in waters of the Japan Current (and north of it).

There are not many broadly tropical species, but most of them are represented on a mass scale. This group includes *Abralia andamanica* Goodrich, *Pyroteuthis margaritifera* (Ruppell), *Onykia cariboea* Lesueur, *Onychoteuthis banksi banksi* (Leach), *Chiroteuthis picteti* Joubin (= *Chiroteuthis imperator* Chun), *Sandalops melancholicus* Chun. Of these, *O. cariboea* and *O. banksi* are circumtropical, *P. margaritifera* and *S. melancholicus* are Atlantic-Indo-West Pacific, *Ch. picteti* is Indo-West Pacific, *A. andamanica* is an Indo-Pacific species. The range of *O. cariboea*, *O. banksi* and *A. andamanica* in the Pacific is primarily equatorial-west central, narrowing down in the east and widened in the west.

Among the species distributed in the equatorial and central waters, we can mention *Enoploteuthis anaspis* Roper, *Histioteuthis hoylei* (Goodrich) (= *H. dofleini*), *Sthenoteuthis oualaniensis* (Lesson), *Cranchia scabra* Leach, *Liocranchia reinhardti* (Steenstrup), *Helicocranchia pfefferi* Massy, *Corynomma abyssicola* (Goodrich). Most are also numerous. *H. hoylei*, *C. scabra*, *L. reinhardti* and *H. pfefferi* are circumtropical, *E. anaspis* is an Atlantic-Indo-West Pacific species, *S. oualaniensis* and *C. abyssicola* are Indo-Pacific. The range of most species is also narrowed down in the eastern part of the ocean: *S. oualaniensis*, *L. reinhardti* and *C. abyssicola* are absent from the California and Peruvian currents, and there is no *C. scabra* in the Peruvian one; only *H. hoylei* and *H. pfefferi* are more widely distributed. All of those species, with the exception of *E. anaspis*, have been reported in the waters of Kuroshio and near Japan (Nesis, 1973a; Shevtsov, 1969; Okutani, 1967). Absence thereof from our catches in the region of the Japan Current indicates that

**Heteroteuthis* sp., discovered by Japanese researchers (Uotani, Ohara, 1974) near the Ryukyu Islands, is apparently referable to this species.

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they are encountered there, but not continuously, being either passively carried from time to time into the Kuroshio from tropical waters or, like *S. oualaniensis*, migrating actively there for feeding.

Many species were encountered in equatorial waters and Kuroshio region, but they avoid central waters, or at least the most oligotrophic parts of the Philippine Sea ("peripheral-equatorial" species). This applies to *Pterygioteuthis giardi* Fischer, *Ctenopteryx sicula* (Verany), *Histioteuthis meleagroteuthis* (Chun), *Disco-teuthis discus* Young et Roper (?), *Mastigoteuthis dentata* Hoyle, *M. atlantica* Joubin, *Belonella belone* (Chun) (= *B. pacifica pacifica* Nesis), *Galiteuthis pacifica* (Robson), *Vampyroteuthis infernalis* Chun, *Jaquetella diaphana* Hoyle. It also includes nerito-oceanic species--*Heteroteuthis* cf. *hawaiiensis* Berry and *Ornithoteuthis volatilis* Sasaki. They are in the benthonic region during the reproductive period, so that their absence from the middle of the Philippine Sea is understandable; they are also absent in the eastern part of the ocean. As for oceanic species, *P. giardi*, *C. sicula*, *H. meleagroteuthis*, *D. discus*, *B. belone*, *V. infernalis* and *J. diaphana* are circumtropical, *M. atlantica* is presumably Atlant-Indo-West Pacific, *M. dentata* and *G. pacifica* are Pacific or, more probably, Indo-Pacific. There are few species represented in large number in this group. Seven out of 10 species were reported near Japan, while 3 even reach the latitude of the Kuril Islands (Nesis, 1973a). The range of *P. giardi*, *D. discus* and *C. sicula* is rather narrow in the eastern part of the ocean, and it does not reach the California and Peruvian currents, while the others are widely distributed. Their absence or scarcity in central waters is unrelated to hydrological barriers. The bathypelagic species in this group (*M. atlantica*, *M. dentata*, *V. infernalis*, *J. diaphana*) perhaps inhabit central waters below depths of 1350-1500 m (bottom range of our catches), although this is unlikely, since their habitat range does not usually go deeper than 700-800 m. Most probably, they avoid central waters because of the shortage of food there.

Quite a few species were not encountered beyond equatorial waters. Most are found in both the Pacific Ocean and Australian and Asia seas: *Enoploteuthis leptura* (Leach), *Abraliopsis lineata* (Goodrich), *Ancistrocheirus alessandrinii* (Verany), *Octopoteuthis megaptera* (Verrill), *Bathyteuthis bacidifera* Roper, *Histioteuthis celetaria* (G. Voss), *Valbyteuthis oligobessa* Young, *Bathothauma lyromma* Chun. Only two of these, *A. alessandrinii* and *B. lyromma*, are circumtropical, *E. leptura*, *O. megaptera* and *H. celetaria* are Atlantic-Indo-West Pacific (*E. leptura* and *H. celetaria* are represented by other subspecies in the Atlantic than in the Indo-West Pacific region), *A. lineata* is Indo-West Pacific, *B. bacidifera* and presumably *V. oligobessa* are Indo-Pacific species.

B. lyromma penetrates rather far to the north in the northwestern part of the Pacific and south in the southeastern part, and probably it is not strictly limited to equatorial waters. Of the other species, only *A. alessandrinii* reaches the coast of southern Japan, while *A. lineata* is encountered in Kuroshio (Shevtsova, 1975; Okutani, 1967; Yamamoto, Okutani, 1975). The species present in the eastern part of the ocean do not travel beyond equatorial waters (with the exception of *B. lyromma*).

The equatorial species discovered only in Indonesian and Philippine seas, or only in the open part of the Pacific, are most often too few in number to define their range with certainty. The nerito-oceanic species, *Spirula spirula* (L.), which

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is distributed in the Atlantic and Indo-West Pacific and does not go beyond the range of areas with closed circulation of intermediate waters (Bruun, 1943), was encountered only in inland seas. *BathYTEUTHIS abyssicola* Hoyle was not encountered in inland seas; the distribution of this species in the tropical parts of oceans is closely related to the distribution of subantarctic intermediate waters (Roper, 1969; Nesis, 1974). The Indo-West Pacific *Abraliopsis hoylei hoylei* (Pfeffer) and *Argonauta boettgeri* Maltzan were also not encountered in inland seas. However, they both penetrate to the shores of Japan and are widely distributed in the Japan Current; their areal distribution in the western part of the Pacific resembles the distribution of equatorial-west-central species.

Pterygioteuthis gemmata Chun, *Hyaloteuthis pelagica* (Bosc), "*Chiroteuthis*" *famelica* Berry, *Liocranchia valdiviae* Chun, *Liguriella* sp. and larvae of Onychoteuthidae, tentatively classified as *Chaunoteuthis mollis* Appellof, were encountered only in central waters. On the northern periphery of central waters, there were *Joubini-teuthis portieri* (Joubin) and *Leachia pacifica* (Issel). *Brachioteuthis behni* (Steenstrup) (= *B. riisei* auct. pt, non Steenstrup) larvae were caught in central waters and Kuroshio. *P. gemmata* is distributed in the Atlantic, Pacific and Indian oceans, its range is bicentral-east equatorial in the Atlantic and northcentral-south-peripheral in the Pacific (Nesis, 1973a, 1974). *H. pelagica* and *Liguriella* sp. are tentatively defined as bicentral species, but in the East Pacific *H. pelagica* enters equatorial waters (Zuyev et al., 1975). The Indo-Pacific species, *L. valdiviae* in the Indian and east Pacific oceans is also often encountered in equatorial waters (Shevtsov, 1973; Clarke, 1966; Okutani, 1974).

There are close relatives of *P. gemmata* and *L. valdiviae* among the widely tropical species *P. giardi* and *L. reinhardti*. *P. giardi* is much more scarce in the region studied than in the East Pacific, it inhabits waters of the Kuroshio system and is also encountered in the Sulu and Banda seas, but is not found in central waters. *L. reinhardti* is represented in very large numbers over the entire tropical zone of the Pacific Ocean, but is less abundant in central waters than equatorial ones. Perhaps the presence of *P. gemmata* and *L. valdiviae* in central waters is attributable to their competitive separation in close waters. *L. valdiviae* and *L. reinhardti* also differ in depth of habitat: *L. reinhardti* is encountered mainly at above 1000 m and *L. valdiviae* at deeper levels.

Previously, *J. portieri* had been found only once in the Pacific near southern Japan. *B. behni* and *L. pacifica* are numerous in Kuroshio and its southern periphery (Shevtsov, 1969; Uotani, Ohara, 1974; Yamamoto, Okutani, 1975), but scarce near Japan; it is impossible to analyze their distribution because of taxonomic difficulties (Nesis, 1973b; Okutani, 1974).

We encountered the following species only in the waters of Kuroshio: *Enoploteuthis chuni* Ishikawa, *Abraliopsis* sp. cf. *falco* Young (*Abraliopsis* type "a" of Shevtsov, 1975), *Taningia danae* Joubin, *Todarodes pacificus* Steenstrup (only larvae), *Ommastrephes bartrami* (Lesueur), *Eucleoteuthis luminosa* (Sasaki), *Cycloteuthis akimushkini* Filippova, *Amphitretus pelagicus* Hoyle. Two types--*T. danae* and *C. akimushkini*--of other parts of the Indo-Pacific region are encountered in the tropics, and there is probably only a seeming coincidence of finding them in the Japan Current. *A. pelagicus* in the West Pacific overtly avoids the tropics, but it is distributed in equatorial waters of the Indian and East Pacific oceans (Thore, 1949; Nesis, 1973a, b). The other species are definitely not tropical. *E. chuni* and *T. pacificus* are nerito-oceanic, subtropical-south boreal species

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distributed in the northwestern Pacific and adjacent seas. *E. luminosa* is bi-peripheral in the Pacific and southern-peripheral in the Atlantic and Indian oceans. *O. bartrami* is a bicentral species, which is distributed in the North Pacific on the northern periphery of central waters, Kuroshio, the North-Pacific drift, California current and region of shifting of subtropical and subarctic waters (Nesis, 1973a; Zuyev et al., 1975). The range of *Abraliopsis* sp. cf. *falco* was not determined; perhaps, this is a peripheral species.

The other species are sporadically distributed in the area; they do not present a clearcut picture and are not included in the above-listed groups.

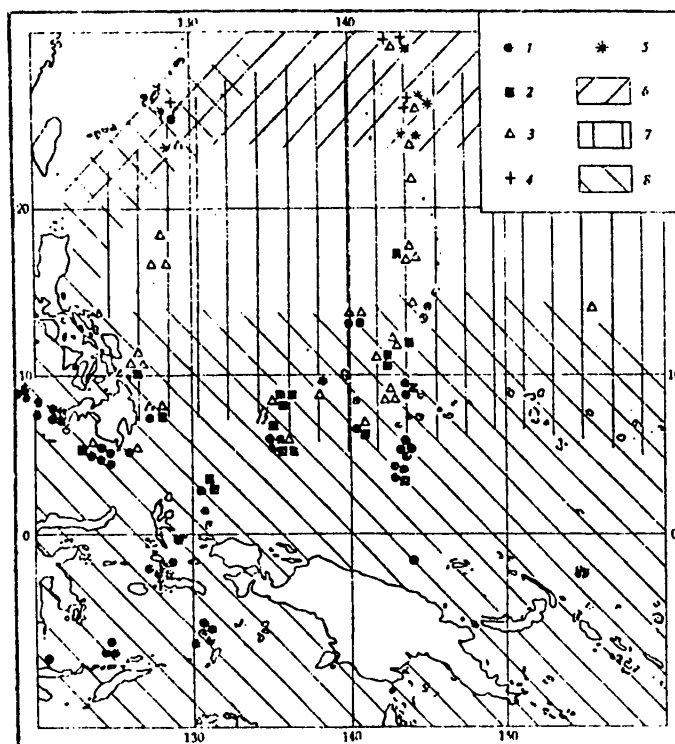
The distribution of geographic groups of oceanic and nerito-oceanic cephalopods in the waters studied was determined only with consideration of their incidence in the studied region. The map (see Figure) shows the sites where the following species were found: 1) Equatorial species distributed in the Pacific and Austro-Asian seas: *Enoploteuthis leptura*, *Abraliopsis lineata*, *Ancistrocheirus alessandrini*, *Octopoteuthis megaptera*, *Bathyteuthis bacidifera*, *Histioteuthis celestaria*, *Brachio-teuthis picta*, *Valbyteuthis oligobessa*, *Bathothauma lyromma*. 2) Equatorial species encountered in the open sea: *Abraliopsis hoylei*, *Abraliopsis* n. sp. (= *A. morisi* Chun, non Verany, part.), *Bathyteuthis abyssicola*, *Lepidoteuthis grimaldii*, *Argonauta boettgeri*. 3) Species encountered in central waters: *Pterygioteuthis gemmata*, "*Chaunoteuthis moliis*," "*Chiroteuthis*" *famelica*, *Liocranchia valdiviae*. 4) Nontropical species encountered in the Kuroshio zone: *Enoploteuthis chuni*, *Onmas-trepes bartrami*, *Eucleoteuthis luminosa*. 5) Species encountered on the periphery of central waters and Kuroshio region, but seen in the tropics in other parts of the ocean: *Joubiniteuthis portieri*, *Leachia pacifica*, *Amphitretus pelagicus*, as well as *Abraliopsis* sp. cf. *falco*, the exact range of which has not yet been defined.

The distribution of the above-listed species shows that there are three latitude zones: equatorial, northcentral (tropical proper) and peripheral (northern subtropical) with wide strips of mixed fauna approximately along 10 and 25° north latitude. Unfortunately, we had no specimens from the extreme western part of the Philippine Sea, north of 15° north latitude, but undoubtedly there is a "corridor" along the western edge of the Philippine Sea that links the equatorial zone to the peripheral one: Taiwan Current, which then goes into the Japan Current. Many equatorial species travel over this "corridor" into the Japan Stream, bypassing central waters (McGowan, 1971).

The north subtropical (peripheral) zone is populated by mixed fauna; broadly tropical species and those distributed in Kuroshio and equatorial waters are constant inhabitants thereof. From time to time, equatorial species pass there also. The northern boundary of this zone traverses the Sea of Japan, Honshu and California; boreal species penetrate into the northern part of this zone (Nesis, 1973a; Okutani, 1968; Young, 1972). On the map of zoogeographic regions of the North Pacific (Nesis, 1973a), the boundary between the northern subtropical and tropical zone in the open part of the ocean is shown to be considerably narrower than ensues from the data submitted above. In actuality, it is a wide band occupying the entire southern half of the peripheral zone.

There are virtually no species inherent solely in the peripheral zone. Among cephalopods, only *Eucleoteuthis luminosa* (Zuyev et al., 1975) is reliably linked with it. This zone is a typical ecotone.

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Zoogeographic partition of tropical West Pacific according to oceanic cephalopods collected during the 50th and 57th voyages of the Vityaz'. The list of species, the sites of finding which are marked on this map, is given in the text

- 1, 2) sites of finding equatorial species distributed in Austro-Asian seas and the open ocean (1) and only in the open sea (2)
- 3) finds of species inhabiting central waters
- 4, 5) finds of species coinciding with the periphery of central waters and the Japan Current system lacking in the tropics (4) and those encountered in the tropics in other regions of the ocean (5)
- 6-8) zoogeographic zones: northern subtropical (peripheral) (6), northern central (7) and equatorial (8)

The above zoogeographic partition of the western tropical part of the Pacific Ocean according to cephalopods is similar to its separation according to zooplankton (Beklemishev, 1969; Geynrikh, 1975; McGowan, 1970) and fish (Parin, 1968). It differs from phytogeographic division (Semina, 1974) in that there is no protrusion of the equatorial zone in the western part of the ocean. In the west of the studied region, northcentral species penetrate rather far to the south, up to the southern part of Mindanao Island, but we failed to observe passage into the southern hemisphere, or penetration of southcentral species into the northern hemisphere. Probably, the northcentral species can penetrate only into the Solomon and New Guinea seas, and then only in insignificant number, just like they seldom penetrate in the Atlantic from the south to the Windward Islands of the Lesser Antilles (Nesis, 1975).

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The region we studied is referable to the Indo-West Pacific geographic tropical region. There are no species in common with the East Pacific region among nerito-oceanic species, whereas among oceanic species, for which zonal ranges are typical, there are fewer in common than species in common with the Atlantic. Of the 70 definitely identified species found during the 50th and 57th voyages, 42-45 (60-64%) are also encountered in the Atlantic Ocean and 39-40 (56-57%) are encountered in the tropical East Pacific. The difference between fauna of the West and East Pacific is attributable more to the paucity of East Pacific fauna, than to the uniqueness of the latter. There are only six endemic species that do not penetrate to the west in the tropical East Pacific: *Enoploteuthis* sp. Okutani, *Abraliopsis affinis* (Pfeffer), *A. falco* Young, *Histioteuthis heteropsis* (Berry), *Valbyteuthis danae* Joubin, *Drechselia danae* Joubin and one more mainly south-tropical species, *Dosidicus gigas* (d'Orbigny). The range of *Neoteuthis* sp. Young was not determined. *Octopoteuthis nielsenii* (Robson) is apparently cosmopolitan. On the other hand, we encountered 22 Indo-West Pacific and Atlantic-Indo-West Pacific species in the West Pacific that were absent from the eastern part of the ocean, but in all there are more than 30 such species. The differences in total number of species in the tropical West and East Pacific are not great, however, since a considerable number of nontropical species penetrate from the south and north into the tropics in the eastern part of the ocean (Nesis, 1973a, b, 1975). Northern species travel south up to 20° north latitude and southern ones travel north up to 5° south latitude. In the western part of the ocean, however, the entire tropical zone from the north tropic to the south is virtually free of nontropical species.

Conclusions

1. The following zoogeographic complexes of oceanic and nerito-oceanic cephalopods are distributed in the tropical western part of the Pacific Ocean, between the Ryukyu and Bonin islands, in the Indonesian and Philippine seas: widely tropical, narrowly tropical (equatorial-central), equatorial, central, widely tropical that avoid central waters and nontropical (inhabiting the peripheral zone and north of it).
2. The widely tropical species that are distributed in the equatorial zone and Kuroshio system apparently avoid central waters because of the oligotrophic nature of these waters. The distribution of some central species is probably attributable to competition with similar widely tropical species that avoid central waters.
3. A considerable part of the narrowly tropical and some equatorial species sometimes penetrate into the Kuroshio region and come up to Japan over the Taiwan Current "corridor."
4. In the tropical West Pacific, between Japan and the equator, there are three zoogeographic latitude zones: northern subtropical (peripheral), northern central (tropical proper) and equatorial, that are connected by strips of mixed fauna at about 25 and 10° north latitude. The northern subtropical (peripheral) zone is an ecotone with mixed fauna and negligible number of specific species.
5. The differences between the fauna of the tropical West and East Pacific are attributable more to the paucity of the East Pacific fauna (7 endemic species) than the uniqueness of this fauna (there are more than 30 species of the West Pacific that are absent from the East Pacific), and as a result the fauna of the tropical West Pacific has more species in common with the Atlantic than with the East Pacific.

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DEVICE FOR FEEDING HIGH-MOLECULAR COMPOUND ONTO WETTED SURFACE

Moscow OPISANIYE IZOBRETENIYA K AVTORSKOMU SVIDETEL'STVU in Russian No 440302,
25 Aug 1971

[Description of invention for Inventor's Certificate for A. A. Tsilikin and V. D. Oparin]

[Text] The invention is related to devices for feeding a high-molecular compound onto a wetted surface of a body moving in water to reduce its drag and can be used in equipment involved in reducing the drag of objects in water.

A device is known for reducing the drag of a torpedo containing a forward-drained streamlined body and internal circular cavity filled with a high-molecular compound. The high-molecular compound is in the form of plates around which flows sea water. However, when investigating the drag of bodies using a high-molecular compound in the form of a pre-prepared solution, the use of the known device is impossible since the internal cavity and its housing are made in the form of a true channel.

The purpose of the invention is to simplify the design of the device and tests when using a high-molecular compound in the form of a pre-prepared solution.

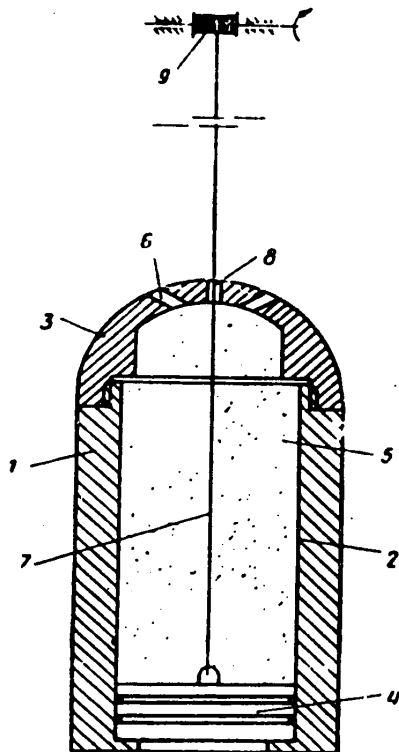
The proposed device is distinguished by the fact that the internal cavity in it is made in the form of a cylinder coaxial with the body in which a piston joined to a tow rope passing through a neutral opening in the bow part of the body is installed.

The proposed device is shown in the drawing.

The device has a body 1, inside which is a cylindrical cavity 2 restricted on one side by the bow part 3 and on the other by a piston 4. The volume of the cavity is filled with a high-molecular compound 5 in the form of a pre-prepared solution. There are drain holes 6 and a pull rope 7 passing through opening 8 and connected to piston 4 and drive 9 in the bow part of the body.

The body 1 is shifted with respect to the piston 4 and forces out the high-molecular compound 5 which envelopes the body of the device through the drain openings 6 when the device moves in the experimental method behind rope 7 due to the force created by the pulling action.

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Object of the Invention

A device for feeding a high-molecular compound to the wetted surface of an axisymmetrical body during towing tests containing a front-drained streamlined body whose internal cavity is filled with a high-molecular compound and a drive, is distinguished by the fact that to simplify the design of the device and for testing when using a high-molecular compound in the form of a pre-prepared solution, the internal cavity in it is made in the form of a cylinder coaxial with the body in which a piston connected to the pull rope passing through the central opening in the bow part of the body is installed.

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HYDROWAVE DEVICE OF MOVING FLOATING PLATFORM

Moscow OPISANIYE IZOBRETENIYA K AVTORSKOMU SVIDETEL'STVU in Russian No 474457, 1975

[Description of invention for Inventor's Certificate for G. N. Rodnikov, N. I. Karzakov, V. M. Grishchenkov and V. A. Pershin]

[Text] The invention is related to shipbuilding.

Hydrowave devices of a moving floating platform are known, for example, ships containing external and internal flexible shells between which are installed elastic components. However, they have high hydrodynamic drag.

To reduce hydrodynamic drag, each of the elastic components is made in the form of a scale-like spring-loaded lever and rack articulately connected to each other and in this case the scale-like lever and rack rest on external and internal flexible shells, respectively, while the lever spring is installed along the hull of the ship.

The described device is shown schematically in profile in Figure 1, a view along arrow A in Figure 1 is shown in Figure 2, a view along arrow B in Figure 1 is shown in Figure 3 and the device in a working compartment is shown in Figure 4.

The scale-like lever 1 of the device is connected by means of spring 2 and hinge 3 to support 4 and in this case the upper end of lever 1 interacts with the external flexible shell 5. The support 3 is attached to an internal flexible shell 6. The device is attached by soldering of the internal shell 6 to the hull 7 of a moving body, for example, a ship (not shown in the figure). A wave 8 flows against the external shell when the ship moves.

The wave of fluid 8 flows in when the ship moves, creating pressure on the external elastic shell 5 and flexing it to a different depth. The surface of the scale-like lever 1 receives the pressure of the wave 8 and is lowered, rotating in the hinge 3 on support 4. The other end of the scale-like lever is raised and releases spring 2. The spring stores potential energy. This operating stroke of the device performs the function of a motor. The potential energy of the spring will be converted to the kinetic energy of motion of the support 4, the internal shell 6 and of the ship when the spring is released. This operating stroke performs the function of an impeller. Spring 2 is compressed when wave 8 flows in, interacting with one end through the scale-like lever 1 and the external elastic shell 5 with

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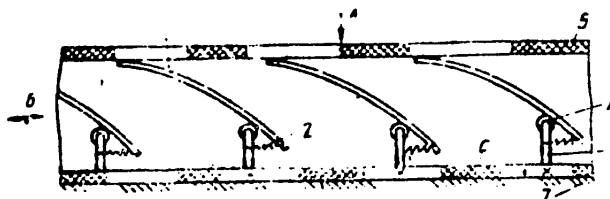


Figure 1.

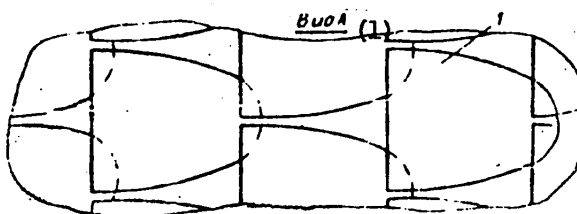


Figure 2.

Key:
1. View A

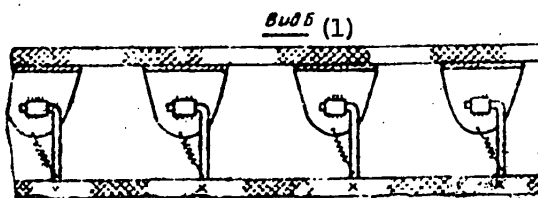


Figure 3.

Key:
1. View B

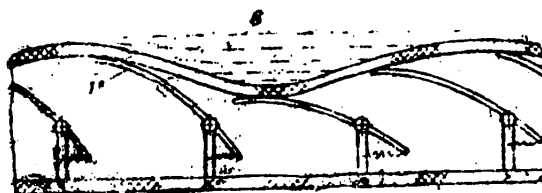


Figure 4.

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the fluid 8. The second end of the spring is held by the support 3. During flexing of the external elastic shell, the second end of the scale-like lever is separated from the support and releases the spring. During release of the spring the support moves in the direction opposite to compression. The spring is released and compressed to an equal length with respect to the dimensions of the ship, but the release of the spring will occur on a larger section of the linear path than compression with respect to the linear path of the ship set in motion by the main impeller.

The device operates when a wave moves along the external elastic shell 5. If static pressure acts on the external elastic shell, uniformly flexing it, the device does not operate. Joining the motor to the impeller does not require additional designs and accordingly additional energy.

Object of the Invention

A hydrowave device of a moving floating platform, for example, a ship containing external and internal flexible shells between which are installed elastic components, is distinguished in that, to reduce hydrodynamic drag, each of the elastic components is made in the form of a scale-like spring-loaded lever and support articulately connected to each other and in this case the scale-like lever and support are connected to external and internal shells, respectively, while the spring of the lever is installed along the hull of the ship.

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DELTA MODULATING MODEL OF RECEPTION

Kiev ELEKTRONNOYE MODELIROVANIYE in Russian No 6, Nov-Dec 81 (manuscript received 24 Apr 80) pp 89-91

[Article by G. D. Dets']

[Text] It is known that an adequate model makes it possible to effectively study the object modeled, reduces organizational and cost-related difficulties in setting up experiments and, in a number of instances, increases significantly knowledge about the modeled object.

In this article, an attempt is made to simulate a biological receptor-sensor by means of a well-known and rather fully studied [1, 2] device, a delta modulator (DM). The proposed model is intended for simulating the electrical activity of a receptor as a reaction to an exogenous stimulus. The qualitative similarity of elementary receptor reactions in objects differing in organization [3, 4], enables us to disregard the specific physical nature and origin of the modeled receptor. Proper coincidence of time plots (sequences of DM output pulses) and the modeled receptor to structurally similar input perturbances served as a criterion of adequacy of the model.

There are neurophysiological data [4] indicating that most perceptive processes are organized by the principle of tracking systems. This circumstance, as well as the fact that the electrical component of a nerve fiber's reaction to an exogenous stimulus is manifested discretely [3, 4], in the form of separate short impulses of about the same amplitude with modulation of duration of intervals between impulses, enabled us to propose a delta modulating model of reception. The model we shall describe reflects the real electrical reaction of a receptor more fully than the well-known "frequency modulating" model [3].

Figure 1 illustrates the block diagram of the DM. Comparator 1 with a hysteretic two-level input-output characteristic has direct and inverse inputs, as well as two outputs--informational, which is connected to the input of key 2, and a control one, which controls the key through lag element 3. The output of key 2 is connected by a diode 4 to local integrator 5. The output of the integrator is shunted with resistor R_p and connected to the comparator's inverse input. Input action [perturbance] (voltage U_i in the model) is fed into the comparator input. Key 2 closes the circuit for a relative brief time, during which capacitance C is charged through resistor R_1 and diode 4 in the event a high potential is established at the comparator output. The circuit for discharge of capacitance C is formed by resistor R_p . Diode 4 serves to separate the circuits for charge

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and discharge of capacitance C . The signal is taken on the recording device (oscillograph, automatic recorder) from the output of the key.

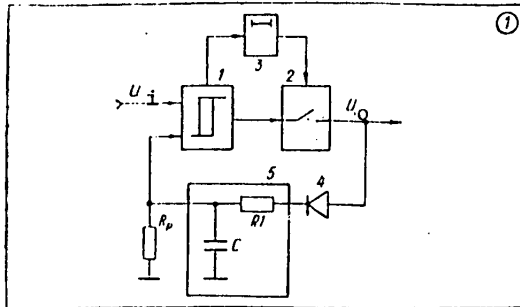


Figure 1.

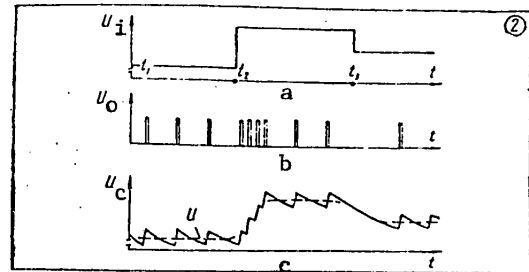


Figure 2.

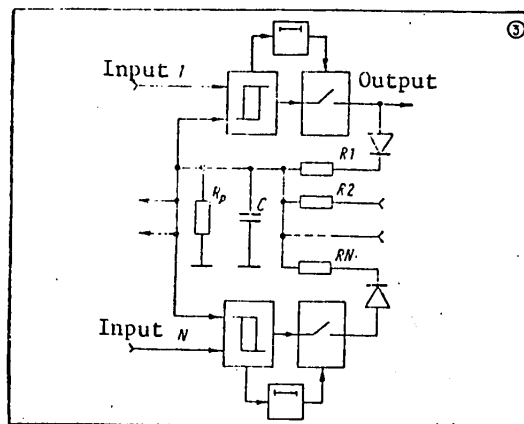


Figure 3.

Figure 2 illustrates the time plots of DM function in typical modes. Figure 2a illustrates the diagram of the external perturbation [input action]. The staggered nature of the test has been used in many studies of neurophysiologists [3, 4] and in engineering practice. Figure 2b shows the output reaction (U_o) of the DM to an input signal. Figure 2c shows voltage U_c formed on capacitance C by the solid line; U_m is the averaged value of U_c .

The DM works over the established level in time interval $T_1 = t_2 - t_1$. The time structure of the pulse sequence in this interval coincides with spontaneous discharges [3, 4] of a resting nerve fiber.

Stepped [staggered] perturbation in interval $T_2 = t_3 - t_2$ elicits the typical DM reaction: at first, the output pulses are frequent, then the intervals between them increase. If interval T_2 is long enough, the DM will change to the mode of tracking the new established level. In neurophysiological categories, the observed phenomena correspond to "reaction to novelty" and "habituation" (adaptation) of the receptor to the exogenous perturbation. An opposite jump, which begins at time t_3 , first causes disappearance of output pulses followed by processing of the third established level if the DM has the necessary time to process the perturbation. If the latter changes faster than the DM can process it (DM is overloaded), the output pulse sequence acquires the appearance inherent in frequency-pulse modulation. Thus, the delta modulating model includes, in specific modes, a frequency modulating model; however, it explains more naturally the "reaction to novelty" and "habituation" modes.

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The DM with the block diagram illustrated in Figure 1 simulates a receptor with an "on" reaction, i.e., one that reacts to positive build-up of perturbation by increasing the number of output pulses per unit time. A model of a receptor with an "off" reaction is obtained if the comparator inputs are switched; then its hysteretic characteristic changes to the opposite sign.

It is known [3, 4] that biological receptors can not only transform the type of input information but also submit it to some degree of primary processing. The delta modulating model of reception makes it possible to develop the most elementary computer and logic devices, as well as to identify multicomponent vector images.

Figure 3 illustrates the block diagram of a device that identifies an N-component vector image. It consists of N DM's which have weighted (by means of R_1, \dots, R_N) access to the general integrator.

The input signals go to N inputs of the DM, some of which are direct and the others are inverted. Approximating voltage is formed on capacitance C under the influence of N channels, and in the established mode its mean value U_m is proportionate to superposition of components from each DM. The appropriate spatial location of inputs in the test environment adjusts the device for the extremum U_m , i.e., makes it possible to identify a specified image.

The technical execution of delta modulating models requires linkage to a specific type of receptor. The structure and parameters of the local integrator are then defined; selection is made of the width of the comparator hysteresis loop and determination is made of the required lag of key commutation. A functional receptor model can be constructed in accordance with the above description on a modern element basis in compact form, or else on a computer.

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CSO: 1840/54

UDC: 62-50

MODELING DYNAMICS OF MOTIVATION IN INSTINCTIVE ANIMAL BEHAVIOR

Moscow PROBLEMY UPRAVLENIYA V TEKHNIKE, EKONOMIKE, BIOLOGII in Russian 1981
pp 196-203

[Article by Ye. A. Faydysh from book "Problems of Control in Engineering, Economics and Biology", USSR Academy of Sciences, USSR Ministry of Instrument Building, Automation Equipment and Control Systems and "Order of Lenin" Institute of Control Problems, Izdatel'stvo "Nauka", 228 pages]

[Text] One of the typical distinctions of instinctive animal behavior in their natural habitat is the rather frequent occurrence of conflict situations. We refer to situations, in which there are simultaneous tendencies toward expressing several incompatible forms of behavior. Numerous experimental studies pursued by ethologists have shown that animals have a number of specific mechanisms that enable them to choose and express a given form of behavior when such situations arise [1]. In spite of the many experimental studies, the principles of organization of the mechanisms that implement behavior in conflict situations are still unclear. At the same time, it is of great practical importance to study instinctive animal behavior in conflict situations. It would permit the development of a number of new automatic [robot] systems expressing complex multigoal behavior in a constantly changing environment, and would permit elaboration of basically new methods of controlling animals.

We offer here a model aimed at the study of the dynamics of factors that motivate different forms of instinctive behavior in conflict situations. Its axiomatics are based on a number of properties of animal instincts, which were discovered and studied by ethologists [2, 3]. The structural unit of the proposed model is the behavior operator whose functions include achieving a specific result and checking presence of conditions in the environment that are favorable for this. In turn, the result of each behavioral operator of a higher level is achieved by reaching a series of local results that are controlled [checked] by operators on lower levels. Interaction between operators on adjacent hierarchic levels is achieved by means of motivational priority (MP) transmitted from higher level operators to lower level operators. There is integration in MP, which determines the choice of a specific operator in a situation conflict, of both the necessity of expression of a given operator and presence of favorable conditions for this in the environment.

At the top level of hierarchy thus organized there are operators that control occurrence of animal needs (hunger, reproductive, defense behavior, etc.). At

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the lowest hierarchic level are the operators that activate the appropriate motor coordination effecting active interaction between the animal and environment during instinctive behavior. In turn, each motor coordination is broken down into stereotype and orienting components. There are a number of ethological works validating such a description of hierarchy of behavioral mechanisms of instinctive behavior [1, 3, 4].

The form of distribution of MP going from an operator to lower level operators is an important factor, which largely determines the typical features of animal behavior. It should be stressed that the MP of this operator not only proceeds toward lower level operators consistent with its goals but to conflicting operators, though to a lesser extent. This has been confirmed by an entire series of experimental ethological studies [1, 2]. Evidently, this property of MP is related to the distinctions of expression of systems controlling instinctive behavior based on neuronal mechanisms.

In this version of the model, two main types of conflict are considered, which arise between different forms of instinctive behavior. We refer, first, to conflict for dominance over the effector system of the animal, which expresses the motor action on the environment; second, for dominance over the perceptual system that effects perception and analysis of signals from the environment. The first variant of conflict occurs chiefly on the lowest hierarchic level of behavior. The second occurs on virtually all hierarchic levels and determines preadjustment of the perceptual system to perception of a particular class of signals. It should be stressed that other variants of conflicts may arise in the course of instinctive behavior, but we can disregard them in the first approximation.

Figure 1 illustrates the hierarchic structure of behavioral mechanisms. As we see from the diagram, a set of triggering stimuli X^m goes to the m th hierarchic level. Let us designate as P^m the set of MP on the m th level. If P_i^m is the MP set of the i th operator on level m ,

$$P^m = P_1^m \times \dots \times P_{i_1}^m \times \dots \times P_{i_m}^m, \quad i \in I_m,$$

where $I_m = \{i: 1 \leq i \leq i_m\}$ is the set of operators on level m and i_m is the number of operators on the m th level.

The MP distribution from each operator on level m goes to operators on the lower ($m-1$) level. Thus, we obtain the display [reflection?]:

$$H_i^m: P_i^m \rightarrow P_i^{m-1}$$

where P_i^{m-1} is the set of priorities going to operators of the ($m-1$)th level from operator i on level m .

The set of priorities P^m coming from the m th level to operators on level $m-1$ will be given by the display:

$$H^m: P^m \rightarrow P^{m-1}$$

Thus, a set of triggering stimuli from environment X^m and a set of MP P^{m+1} from a higher level pass to each hierarchic level. This level effects display K^m :

$$K^m: P^{m+1} \times X^m \rightarrow P^m.$$

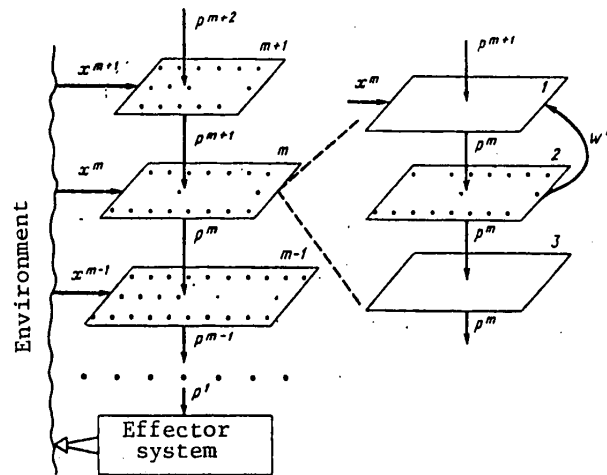


Figure 1.

Each level of this hierarchy has a multilayer structure that effects the next displays. In the first layer there is analysis of adequacy of the triggering situation in the environment with consideration of preadjustment, and the cartesian product of sets p^{m+1} , x^m , w^m is reflected in the set of motivation priorities p^m of level m :

$$S^m: p^{m+1} \times X^m \times W^m \rightarrow P^m.$$

w^m is the set of signals for preadjustment from operators on the m th level and it is given by display C^m :

$$C^m: p^m \rightarrow W^m$$

The third, last layer effects display $H^m: p^m \rightarrow p^{m+1}$. Although the MP of operator i on level m is reflected on all operators on the lower $m-1$ level, in set I_{m-1} we single out a subset of adequate operators I_{m-1}^i which is characterized by considerably higher values of motivational priorities coming to its operators from the i th operator on the m th level. It should be noted that for any two operators i and j of level m , the set $N_{m-1}^{i,j} = I_{m-1}^i \cap I_{m-1}^j$ determines common operators for them on level $m-1$, which can effect ambivalent behavior. On the other hand, the conflicting operators belong to set $L_{m-1}^{i,j} = I_{m-1}^i \Delta I_{m-1}^j$.

The animal's effector system consists of a set of stereotypes R_g and set of orientation channels R_k . Each configuration of motor action is given by the operator of the lowest, first level by means of display $H_i^1: p_i^1 \times p_i^1 \rightarrow p_i^1$, where $p_i^1 = p_{i,j_1}^1 \times \dots \times p_{i,j_n}^1 \times \dots$, $j_n \in D_i$.

$D_i \subset R_g \cup R_k$, and it is the set of stereotypes and orientation channels that make up the adequate motor action. Some of the channels of orientation and stereotypes that require the same degrees of freedom of the animal's body for their expression are incompatible, i.e., they cannot be expressed simultaneously. Let us designate

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with Q the set of elements of the effector system that are incompatible in pairs. Then, from the definition of adequate behavioral action it directly ensues that $D_i \times D_j \cup Q = \emptyset$. If several actions are activated simultaneously, the set of conflicting channels of orientation and stereotypes $L^{i,j}$ will be given by expressions $D_i \times D_j \cap Q$. In this case, of each pair belonging to $L^{i,j}$ an element will be chosen that has maximum priority. Thus there will be formation of the motor action containing both D_i and D_j elements, and consisting of compatible channels of orientation and stereotypes. As shown by the observations of ethologists, such movements do indeed occur in certain conflict modes, and they play a large part in reproductive and territorial behavior of animals [1-3].

We used the hydraulic model of motivation proposed by K. Lorenz [2] to derive the system of differential equations describing the dynamics of redistribution of MP among behavior operators on different hierarchic levels. It was considered that the intensity of MP going to each operator depends on evaluation of the degree of adequacy of triggering conditions in the environment. In turn, the evaluation of degree of adequacy is affected both by the state of the environment and preadjustment of the perceptive system. Inertia of change in MP of the j th operator on the m th level was set by parameter C_j^m , which depends on the specific distinctions of the form of behavior under study.

Thus, proceeding from the applicability of hydraulic analogy to processes of redistribution of motivation, we obtained the following system of equations:

$$\begin{aligned} \dot{P}_1^{v-1} &= \frac{1}{C_1^{v-1}} \left(\sum_{i=1}^{n_v} S_i^{v-1} H_{i,1}^v (P_i^v - P_1^v) - \sum_{k=1}^{n_v} S_k^{v-2} H_{1,k}^{v-1} (P_1^{v-1} - P_k^{v-1}) \right), \\ &\dots\dots\dots \\ \dot{P}_j^m &= \frac{1}{C_j^m} \left(\sum_{i=1}^{n_{m+1}} S_j^m H_{i,j}^{m+1} (P_i^{m+1} - P_j^m) - \sum_{k=1}^{n_{m-1}} S_k^{m-1} H_{j,k}^m (P_j^m - P_k^{m-1}) \right), \\ &\dots\dots\dots (1) \\ \dot{P}_{n_m}^1 &= \frac{1}{C_{n_m}^1} \left(\sum_{i=1}^{n_1} S_{n_m}^1 H_{i,n_m}^1 (P_i^1 - P_{n_m}^1) - L_{n_m} P_{n_m}^1 \right) \end{aligned}$$

where $H_{i,j}^m$ is the parameter of distribution of MP of the i th operator on level m , v is the number of levels in the model, n_m is the number of operators on the m th level, P_j^m is the magnitude of MP of the j th operator on the m th level, S_j^m is the perceptual evaluation of adequacy of ambient conditions for j th operator of the m th level, L_j is a variable characterizing passage of MP to the effector system.

The values of variables S_j^m and L_j depend on the form of behavior that dominates over the perceptual and effector systems, and they are determined using the following expressions:

$$S_j^m = \begin{cases} S_j^m(x), & \text{if } P_j^m > P_i^m \forall i, \\ S_j^m(x) \cdot S_k^m(x_j^m), & \text{if } \exists k: P_k^m > P_j^m, \end{cases}$$

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where x is the variable describing the state of the environment at a given point in time, x_j^m is the value of the variable state of the environment that is optimal for expression of the j th operator on the m th level, k is the number of the operator that dominates at the given level.

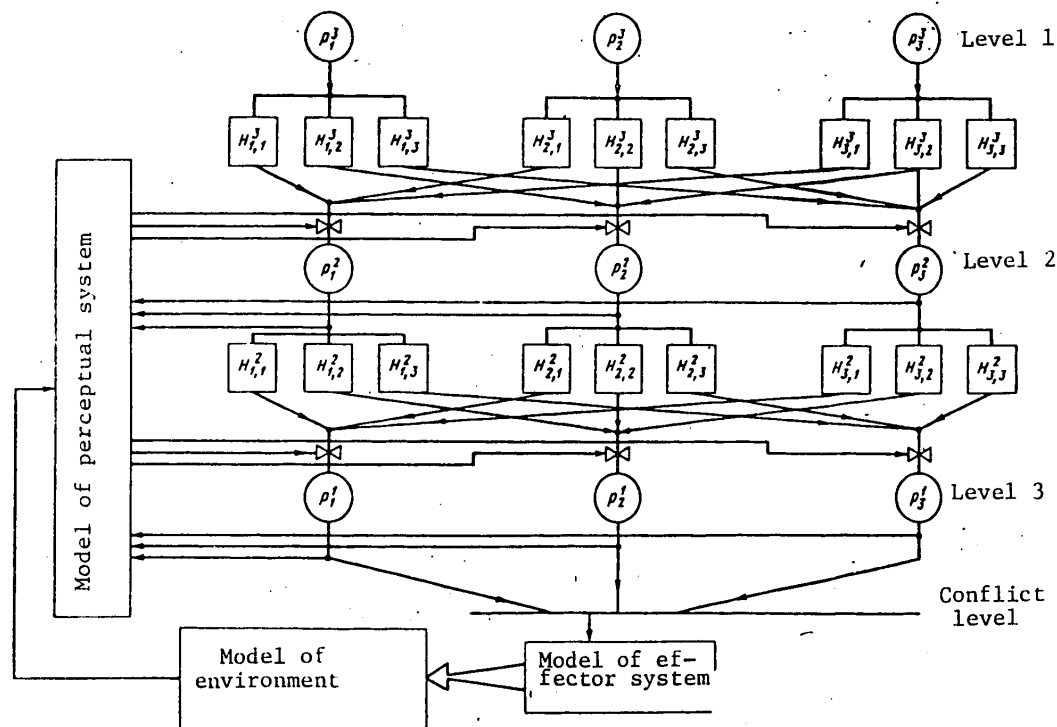


Figure 2.

It is important to stress that an operator with maximum MP at a given point in time dominates on each hierarchic level.

The value of L_j is determined using the following expression:

$$L_j = \begin{cases} L_n, & \text{if } P_j^1 > P_i^1 \forall i, \\ L_x, & \text{if } \exists k: P_k^1 > P_j^1, \end{cases}$$

where L_x determines the outlay of MP with the operator in a passive state and L_n gives the outlay of MP with dominance of a given operator over the effector system.

System (1) of differential equations enables us to investigate different modes of conflict between two, as well as several forms of behavior. It was used to create

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a dynamic simulation model on a digital computer aimed at the study of conflict between two or three forms of behavior with a three-level hierarchy. The state of the environment was described by a one-dimensional numerical parameter, and it could be given as a function of time or by means of a chart whose peaks consisted of different states of the environment, while the motor reactions of the animal model served as the edges.

Figure 2 illustrates the block diagram of the simulation model of conflict in instinctive behavior. Some of the behavioral operators are shown there in the form of circles.

A study of the dynamic characteristics of conflict using this model made it possible to develop a basically new method of objectivizing the structural units of instinctive behavior [5] based on the fact that, according to the model, with successive change in behavior operators there should be stepped change in magnitude of MP. Such stepped change in MP was confirmed in experiments with caddis-fly larvae [6] using the method of conflict interruption, which was also developed on the basis of this model. At the present time, the proposed objectivization method and method of conflict interruption are used in a number of studies dealing with animal instincts.

In addition, this model made it possible to predict the existence of the phenomenon of stability of dominant behavior operators, as well as to investigate the effects of various endogenous and exogenous factors on stability, study the causes of onset of pathologically stable states and inadequate modes of behavior in conflict situations.

Since the proposed model describes rather general features of instinctive behavior in conflict situations, after appropriate modification it was found adequate for investigation of dynamics of conflict in the system of physiological homeostasis. A study of disturbances referable to processes of physiological homeostasis using this model made it possible to propose new methods of nonspecific therapy and to develop a number of basically new devices for treating the acupuncture points of the human body. At the present time, the proposed methods and equipment are being used with success in the Department of Clinical and Hospital Surgery at the People's Friendship University imeni Lumumba, Second Central Design Office of MPS [expansion unknown] and Central Children's Hospital in Rostov-na-Donu.

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DISTRIBUTION OF DYNAMIC PRESSURE ON BODY OF ACTIVELY SWIMMING DOLPHIN

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 261, No 2, Nov 81 (manuscript received 10 Feb 81) pp 310-312

[Article by Ye. V. Romanenko, Institute of Evolutionary Morphology and Ecology of Animals imeni A. N. Severtsov, USSR Academy of Sciences, Moscow (submitted by Academician V. Ye. Sokolov on 20 Jan 81)]

[Text] In 1936, the English zoologist, James Gray [1], expounded the hypothesis that the critical Reynolds number of an actively swimming dolphin must be higher than in a dolphin swimming by inertia or a rigid model in the shape of a dolphin. This could be caused by negative pressure gradient on the body of an actively swimming dolphin, which Gray assumed existed on the basis of speculation and rather naive considerations. Nevertheless, Gray's hypothesis is apparently true, as indicated by the results of this study.

In the course of active swimming, the dolphin's body oscillates transversely, and the amplitude of oscillations increases from the head to the tail. This is the so-called locomotor wave that causes appearance of thrust. It can be demonstrated that the locomotor wave also leads to formation of a negative pressure gradient along the dolphin's body in the direction from head to tail, and its magnitude is quite sufficient for raising appreciably Reynolds' critical number.

In the first approximation, it can be considered that the dolphin's body is cylindrical, and the section of the body changes little over its length. In this case, the distribution of pressure on the body surface is determined by the well-known equation [2]:

$$P - P_{\infty} = \frac{\rho v_y^2}{2} \left(1 - 4 \sin^2 \theta \right) + \frac{\rho \cos \theta}{R} \frac{d}{dt} (R^2 v_y); \quad (1)$$

where $v_y = v_y(x, y)$ is the velocity of transverse body movement,

$$v_y = \frac{\partial \eta}{\partial t} + V \frac{\partial \eta}{\partial x}, \quad (2)$$

R and θ are coordinates of points on the body surface, ρ is density of water, $\eta(x, t)$ is amplitude of transverse oscillations of the body and V is longitudinal velocity of the body.

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In equation (1), the unknown is the velocity of transverse body movements. This parameter can be found if the law of body deformation is known. The law of deformation for the dolphin's body during active swimming has been proposed in the following form [3]:

$$\eta = \eta_1 \left[K_r - 1 + \exp \left[\alpha \left(\frac{x}{L_p} \right)^\gamma \right] \right] \sin \omega \left[t - \frac{x}{C_r(1+bx)} \right]; \quad (3)$$

where η_1 is the amplitude of oscillations of the tail, K_r is the ratio of amplitude of head oscillations to tail oscillations, ω is circular frequency, t is time, C_r is phasic velocity of locomotor wave in the region of the head, γ is the coefficient of degree of build-up of amplitude of locomotor wave, b is the parameter characterizing phasic velocity of the locomotor wave as a function of coordinate in the system of coordinates related to the animal's body and $\alpha = \ln(2 - K_r)$. The position of the dolphin's body in this system of coordinates is illustrated in Figure 1.

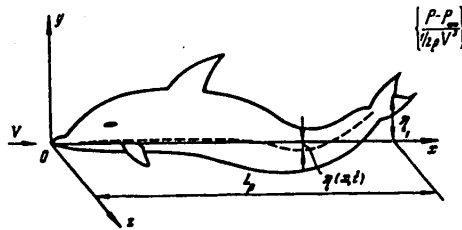


Figure 1.
Position of dolphin in
system of coordinates

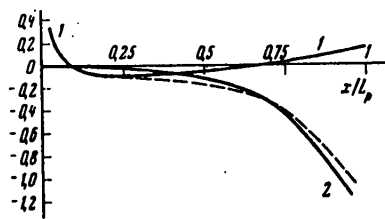


Figure 2.
Distribution of dynamic pressure on
lateral surface of dolphin's body

Expressing formula (1) in a dimensionless form and with averaging of time, we shall have:

$$\left\{ \frac{P - P_\infty}{\frac{1}{2} \rho V^2} \right\} = \frac{\{v_y^2\}}{V^2} (1 - 4 \sin^2 \theta). \quad (4)$$

Applying the adopted law of deformation of the dolphin's body (3), equation (4) can be finally written down in the following form:

$$\begin{aligned} \left\{ \frac{P - P_\infty}{\frac{1}{2} \rho V^2} \right\} = & \left(\frac{\omega^2 \eta_1^2}{2V^2} \left[1 - \frac{V}{C_r(1+bx)} \right]^2 \left[K_r - 1 + \exp \left[\alpha \left(\frac{x}{L_p} \right)^\gamma \right] \right]^2 + \right. \\ & \left. + \frac{\alpha^2 \gamma^2 \eta_1^2}{2L_p^2} \left[\frac{x}{L_p} \right]^{2\gamma-2} \exp \left[2\alpha \left(\frac{x}{L_p} \right)^\gamma \right] (1 - 4 \sin^2 \theta) \right. \end{aligned} \quad (5)$$

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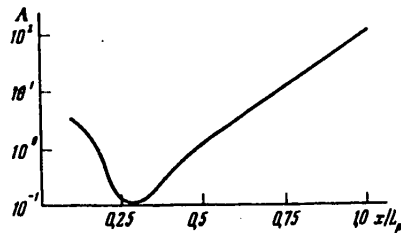


Figure 3.

Distribution of form parameter of velocity profile in boundary layer on lateral surface of dolphin's body

As an example, let us calculate the distribution of pressure on the body of the bottlenosed dolphin in the swimming mode which is considered by some researchers [4] to be preferred by dolphins. We shall take the kinematic parameters corresponding to the preferred swimming mode, which are needed for calculations, from [5, 6], in which these parameters were obtained experimentally (Table 1).

Figure 2 (curve 2) illustrates the results of calculating dynamic pressure on the lateral surface of the body of the bottlenosed dolphin (with $\theta = \pm\pi/2$). In the same figure (curve 1) is shown the distribution of dynamic pressure on a solid of revolution that is closest to the dolphin body. These data were taken from [7] and correspond to model No 28. The dash line in Figure 2 shows overall pressure calculated on the assumption that the additivity principle applies. We were impressed by the monotonously dropping function of overall pressure, which is indicative of presence of negative pressure gradient over the entire dolphin body, from head to tail, and the negative pressure gradient is considerably higher in the region of the head and stalk of the tail than in the middle part of the body.

Table 1.

n_1/L_p	f, c^{-1}	$V/L_p, \text{c}^{-1}$	b, m^{-1}	γ	L_p, m	K_r	V/C_r
0,22	1,1	0,65	0,23	4,6	2,24	0,22	0,95

Let us estimate the form parameter of the velocity profile in the laminar boundary layer on the dolphin body, determined with the equation [8]:

$$\Lambda = - \frac{\delta^2}{\nu \rho V} \frac{dP}{dx}, \quad (6)$$

where ν is kinematic viscosity and δ is thickness of the boundary layer. Figure 3 illustrates the distribution of form parameter of the profile of velocities in the boundary layer on the dolphin body. The nature of distribution of the form parameter enables us to derive the following conclusions:

- 1) in the dolphin there must be a 3-4-fold increase in Reynolds' critical number estimated for body length;
- 2) turbulization of the boundary layer must start in the central part of the dolphin body, where the form parameter has lowest values.

The presence of a negative pressure gradient on the body of an actively swimming dolphin, as well as its effect on the fine structure of the turbulized boundary layer, have already received experimental confirmation [9, 10].

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BIOTECHNOLOGY

UDC: 62-523.2

MAGNETIC AND MAGNETO-SEMICONDUCTOR ELEMENTS FOR INFORMATION PROCESSING

Moscow MAGNITNYYE I MAGNITO-POLUPROVODNIKOVYYE ELEMENTY DLYA PERERABOTKI
INFORMATSII in Russian 1981 (signed to press 20 Jan 81) pp 2, 8-13

[Annotation and article by M. A. Rozenblat and A. A. Romashchev from book
"Magnetic and Magneto-Semiconductor Elements for Information Processing", edited
by Prof M. A. Rozenblat, doctor of engineering sciences, Izdatel'stvo "Nauka",
2000 copies]

[Text] This collection deals with the study of magnetic semiconductor elements and devices for processing analogue and digital information, as well as memory units with data carriers in the form of cylindrical magnetic domains (CMD). There is discussion of the means of constructing high-frequency restorable elements and commutation elements with high reliability, forecasting elements on magnetic analogue memory units, units involving the use of magnetic semiconductor sensors for prestart monitoring. It is intended for scientific, engineering and technical workers.

UDC: 681.332:612.172.2

Use of Units for Dynamic Analysis of Random Processes in Biomedical Studies

[Article by M. A. Rozenblat and A. A. Romashchev]

[Text] One of the important directions of development of modern medical instrument building is related to elaboration of methods for analysis, diagnostics and prognostics based on consideration of the human body as a dynamic system, the patterns of function of which have stochastic components, in addition to deterministic ones. The required instruments must determine immediately [dynamically, directly] on a real time scale the main parameters of both components of the biomedical process or phenomenon under study. The results of analysis must be submitted to the observer (medical personnel) in a form that is convenient for immediate use without any further processing. The instruments must not require special technical knowledge on the part of medical personnel, they must be convenient to service, impervious to noise and effect analysis of the phenomenon under study for a rather short period of time, which is necessary for effective use thereof in the case of screening and checking the condition of a large number of patients.

The electrocardiographic signal (ECS), electroencephalographic signal (EES), electric biopotentials of individual points or parts of the body, etc., are typical parameters of the body that have determined and stochastic components. The same signal components appear when using various active methods of biomedical studies, involving

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the use of exogenous factors on some organ or other, for example, sound, source of radiation, photic pulses, etc., and determination of its reaction.

Determination of the informative tags of a biomedical phenomenon or process containing stochastic components requires many measurements and labor-consuming calculations, and for this reason automatic methods of analysis based on the use of general purpose or specialized computers are used predominantly. Although microcomputers or standard microprocessor units can often be used, if their memory is large enough, the difficulty of technical execution of the analytic system usually limits the area of their application in dynamic, stochastic methods of analysis of biomedical processes, and makes it impossible or impractical to use monitoring and measuring equipment as a bedside monitor. Expanded use of these methods in both scientific research and medical practice could lead to development of inexpensive specialized instruments that take into consideration the specifics of the analysis in question.

The processes that occur in a living organism may be either continuous (for example, blood pressure) or discrete (for example, duration T_i of cardiac cycles). It is a known fact that any continuous process can be analyzed, with virtually no loss of accuracy, by the method of discrete samples and, consequently, the equipment that operates on this principle acquires a universal character. For this reason, we shall discuss only the discrete presentation $\{x_i\}$ of a random process $x(t)$ at time t_i .

For dynamic analysis of the parameters of process $\{x_i\}$, it is the most expedient to use recurrent algorithms. In this case, evaluation of parameters can be obtained at the same pace as input of the next value of x_i and, consequently, one can reduce data processing time to the maximum extent.

The main characteristics of random processes include mathematical expectation $M[x]$ and dispersion $D[x]$. The recurrent algorithm for calculation thereof has the following appearance [1, 2]:

$$M_{i+1} = M_i + \gamma_i (x_{i+1} - M_i); \quad D_{i+1} = D_i + \gamma_i [(x_{i+1} - M_i)^2 - D_i], \quad (1)$$

where M_i and D_i are evaluations of mathematical expectation and dispersion of process $\{x_i\}$, respectively, and γ_i is a certain sequence of numbers. One can use, for example:

$$\gamma_i = 1/(i + 1), \quad i = 0, 1, 2, \dots \quad (2)$$

Evaluation of standard deviation is $\sigma_i = \sqrt{D_i}$

As can be seen in (1), calculation of M_i and D_i is made using a similar algorithm:

$$Q_{i+1} = Q_i + \gamma_i (z_{i+1} - Q_i). \quad (3)$$

With $z_i = x_i$, we obtain the estimate of M_i , and with $z_i = (x_i - M_{i-1})^2$, the estimate of D_i . It is easy to obtain a function of the (3) type using integral semiconductor operational amplifiers and digital elements according to the scheme given in [2]. Let us call the corresponding device the averaging unit (AU). The intrinsic distinctions of the AU of this type are discussed in [2, 3]. It is convenient to render the computer of static characteristics of random processes on the basis of such AU's, which makes it possible to obtain estimates on a real time scale of mathematical expectation, dispersion standard deviation and coefficient of variation of both continuous and discrete random processes.

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Filtration of ejects (interference) in the run under study, which could distort substantially the obtained data, is an important task that arises in developing instruments for analysis of random biomedical processes. These ejects may be caused by superposition of other random processes on the one under study, technical noise, etc. For example, when analyzing the heart rhythm according to electrocardiographic signal, ejects may be caused by temporary rhythm disturbances (electrosystole, etc.) or technical noise (artefacts) caused by impaired electrode contacts, movement of the patient, etc. One can eliminate the influence of such ejects on the results of determination of mathematical expectation and dispersion of the studied (uncontaminated) process if the permissible values of process $\{x_i\}$ are only those that satisfy the following condition:

$$|x_{i+1} - M_i| \leq k\sigma_i, \quad (4)$$

where k is a constant that is determined mainly by probability α of appearance of major noise (ejects). We can demonstrate that for typical values of $\alpha = 0.01-0.1$, $k \approx 3$.

Formula (4) is the solving rule for determination and rejection of "suspicious" values of the process or ejects. To make practical use of rule (4) for analysis of process $\{x_i\}$ on a real time scale, we must have either at least approximate a priori estimates of $M^*[x]$ and $\sigma^*[x]$, or else they must be found in the course of analysis. In the latter case, part T_1 of total analysis time T_A is used for the initial rough estimate of parameters $M^*[x]$ and $\sigma^*[x]$. For this purpose, during time $T_1 \ll T_A$, we can select $\sigma^* = \sigma_{\max}$, where σ_{\max} is the maximum possible value of σ^* , and one can use the current mean of process $\{x_i\}$ as M^* . In view of the fact that the probability of ejects is usually low, the initial estimates of M^* and σ^* obtained in time T_1 in (4) will correspond to the sought estimates with a probability of close to one. During the main period of analysis $T_1 \ll t \ll T_A$, the values of M^* and σ^* in (4) are determined by the current estimates of these parameters, i.e., there is continuous adaptation of the unit that selects values of $\{x_i\}$ which satisfy condition (4) in a specific run of process $\{x_i\}$.

Several instruments were developed on the basis of algorithm (1) and solving rule (4), for determination of the parameters of various biomedical processes. We shall dwell in greater detail on one of these instruments, the "Cardiorhythm," which is intended for dynamic measurement of the main statistical characteristics of cardiac rhythm [4].

Analysis of cardiac rhythm from the standpoint of random processes and theory of transient processes enables us to obtain the data that are required for fuller understanding of the mechanisms of regulation of a number of body functions, evaluation of the condition of the heart and organism in certain clinical situations and for diagnostics of diseases.

A study of the parameters characterizing heart rhythm revealed that the most informative ones include the mean value and standard deviation of duration of cardiac cycles. These parameters are of great interest for the following reasons. On the one hand, they characterize the correlation between central and autonomic nervous regulation in forming the heart rhythm, being also the main parameters of density of distribution of cardiac cycles, and, on the other hand, they are not too complicated for determination by instruments.

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It is convenient to determine the duration of cardiac cycles according to RR intervals of the ECS. Let us designate the duration of the i th cardiac cycle as RR_i and mean value and standard deviation as \overline{RR} and σ_{RR} , respectively. Parameter \overline{RR} determines the mean pulse rate and σ_{RR} the mean arrhythmia. Calculation of σ_{RR} involves operations of raising to the second power and extraction of the square root. This complicates the equipment.

To make things simpler, parameter $\Delta\overline{RR}$, which can be easily calculated, is used in the Cardiorhythm instrument, and it is found with the following equation:

$$\Delta\overline{RR} = \frac{1}{N} \sum_{i=1}^N |RR_i - \overline{RR}|,$$

where $\overline{RR} = \frac{1}{N} \sum_{i=1}^N RR_i$, and N is the number of cardiac cycles, i.e., $\Delta\overline{RR}$ is the mean modulus of deviation of RR_i intervals from \overline{RR} . The number N of cardiac cycles is selected in accordance with the required size of the sample (duration of measurement). With a given law of distribution, σ_{RR} and $\Delta\overline{RR}$ are related by a linear function, $\Delta\overline{RR} = \beta\sigma_{RR}$. With the Gaussian law of distribution of RR_i intervals, which usually governs normal (sinus) cardiac rhythm, $\beta = 0.8$.

Abnormal RR_i intervals, related to either extrasystoles or artefacts, are eliminated in the instrument by means of a filter that realizes the above-mentioned solving rule (4). Each appearance of an abnormal RR_i interval causes a pulsed flashing of a light. In some special cases, for example, auricular fibrillation, one can disconnect signal filtration.

The Cardiorhythm instrument can operate in the mode of single calculations with automatic stops after the 64th, 128th or 256th cardiac cycle and storage of the results. When used in a monitoring system, there is automatic repetition of calculations. There are provisions in the instrument for setting threshold values \overline{RR}_t and $\Delta\overline{RR}_t$. If even one of parameters \overline{RR} and $\Delta\overline{RR}$ exceed the range set for a given patient, there are audio and light signals that appear.

The preamplified ECS or pulsed signal from a digital sensor can serve as input signal. The results of calculating \overline{RR} and $\Delta\overline{RR}$ are shown on dials with needles, and they can be put out in analogue form from the external terminals of the instrument for graphic recording or input in a computer.

The Cardiorhythm is a specialized instrument based on integrated microcircuits.

Instruments of the Cardiorhythm type have been used to analyze cardiac rhythm in diverse biomedical examinations, such as complex evaluation of a patient's condition in the course of preoperative preparation, during surgery and in the post-operative period; complex evaluation of the condition of patients with ischemic heart disease; evaluation of drug therapy and preparation of a patient for defibrillation in the presence of auricular fibrillation; evaluation of the state of patients' cardiovascular period at the acute stage of myocardial infarction and at the stage of physical rehabilitation to predict endurance of physical loads; complex evaluation of the state of an operator in the presence of psychoemotional loads, etc.

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Main Specifications for Cardiorhythm Instrument

Range of measurements	
mean \overline{RR} , s	0.2-1.5 (40-300 beats/min)
mean deviation $\Delta\overline{RR}$, ms	0-50; 0-100; 0-300
Main index error (when outputting signals to external terminals), %	
mean \overline{RR}	No more than 1
mean deviation $\Delta\overline{RR}$	No more than 3
Ambient temperature, °C	10-35
Relative ambient humidity, %	Up to 80
Alternating current	
frequency, Hz	50-60
voltage, V	220±10%
Power consumed, W	30
Dimensions, mm	324×360×124
Weight, kg	7.5

The results obtained in the above directions revealed that Cardiorhythm instruments yield valuable biomedical information. They operate reliably and are simple to use, so that they can be serviced by paramedical personnel. The speed and ease of handling the instrument make it possible to use it not only in hospitals, but for mass screenings at polyclinics.

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MEDICAL DEMOGRAPHY

UDC: 616.98:578.832.1]-036.8"1979-1980"

SYMPTOMATOLOGY AND OUTCOME OF SEVERE AND COMPLICATED FORMS OF INFLUENZA DURING 1979-1980 EPIDEMIC

Moscow TERAPEVTICHESKIY ARKHIV in Russian Vol 53, No 10, Oct 81 (manuscript received 3 Dec 80) pp 18-21

[Article by A. A. Alekseyeva, A. E. Radzevich, N. I. Gaydukova, A. B. Bezprozvanny and V. N. Martynova, Clinical Department (headed by Prof Ye. S. Ketiladze) of the Institute of Virology imeni D. I. Ivanovskiy (director--V. M. Zhdanov, academician of the USSR Academy of Medical Sciences), USSR Academy of Medical Sciences; chair of therapy, Faculty for Advanced Training of Physicians (headed by Prof V. N. Orlov), Moscow Medical Stomatological Institute imeni N. A. Semashko, based at Municipal Clinical Hospital No 52 (acting chief physician--Z. F. Yerkhova), Moscow]

[Text] After the appearance of influenza A virus [Hongkong/1/68 (H3N2)] altered variants thereof began to be detected more and more often. This circumstance caused almost annual epidemics of influenza varying in intensity (I. V. Antonova). The influenza epidemic in Moscow, which occurred in December 1979 -- January 1980, was caused by A virus [Texas/1/77 (H3N2)] and antigen-related A strains (H3N2-Bangkok).

More than 800 patients with influenza were hospitalized in therapeutic departments of Municipal Clinical Hospital No 52, which were respecialized for the duration of the epidemic.

In this report, we submit clinical, laboratory and functional data on 25 patients who were admitted to the intensive care unit because of the severity of their condition. The diagnosis of influenza had been confirmed in all 25 cases by laboratory tests--demonstration of influenza antigen in the respiratory tract by the immunofluorescence method (in 11 out of 16 cases, including 4 post mortem) and diagnostic increment of antibody titer in serological tests (hemagglutination inhibition and complement fixation tests).

This group of patients ranged in age from 15 to 81 years, but there was prevalence of young people. Thus, there were 9 patients 15-30 years of age, 6 who were 31-50 years old, 5 51-55 years old and 5 over 70 years of age. They were hospitalized at different stages of illness: 10 within the first 3 days, 13 on the 4th-7th days and 2 on the 9th day.

The condition of 17 out of the 25 patients was judged extremely serious and, in the other 8, serious.

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Seriousness of condition upon admission was largely due to both severe toxicosis and complications referable to respiratory organs (23 out of 25 cases), primarily pneumonia (19 cases) or diffuse bronchitis (4). Two patients (15 and 21 years old) had no pulmonary complications. In addition, concomitant diseases, exacerbated under the influence of influenza infection, affected the severity of condition, particularly among the elderly (11 cases): chronic ischemic heart disease (7), chronic nonspecific lung disease (2), blood disease (1) and severe diabetes associated with diabetic coma (1).

All clinical signs of influenza infection were present. It was characterized by acute onset, rapid elevation of temperature and concurrent intensive buildup of toxicosis (see Table). All patients presented headache, exhaustion, aches and pains (22 cases), not infrequently severe adynamia, inhibition (19), chills (18), vertigo (18), as well as changes in the vascular and central nervous system--unconsciousness and meningeal symptoms (12), syncope (3) and others. In most cases, maximum temperature was 40°C or higher (14 cases), and it constituted 38.4°C in only 2 patients (presenting signs of pneumonia, who subsequently expired).

All of the patients presented cyanosis of mucous membranes and skin, which was sometimes extremely marked, to the extent of severe cyanosis. Many had hemorrhagic symptoms in the form of petechial hemorrhages of the mucous membrane (16 cases), nosebleed (4) and admixture of blood in sputum (9).

The respiratory tract was involved in all patients, as manifested by cough (24 cases), marked tracheitis or laryngotracheitis (18) and moderate rhinitis (13).

The severity of the patients' condition, particularly in cases complicated by pneumonia or bronchitis, was due primarily to respiratory insufficiency (21 cases) and in most cases developed or incipient pulmonary edema (13), cerebral edema (12), acute cardiovascular insufficiency (6) with marked toxicosis. Toxicosis was observed both in elderly patients with massive pneumonia and young people who presented no complications.

It is known that bacteria play a rather important role (F. G. Epshteyn; Ye. S. Ketiladze et al.) in the pathogenesis of complicated forms of influenza, along with influenza virus, but in essence there is development of both viral and bacterial infection, manifested by specific clinical symptoms, in the severe and complicated cases of influenza.

Superposition of bacterial infection caused deeper involvement of bronchi in the process, with very distinct signs of acute or exacerbated chronic bronchitis (8 cases). A dry cough (24) was observed only at the early stages of illness. On subsequent days, the sputum became mucoid or mucopurulent (19). Nine patients had an admixture of blood in sputum, some developed massive hemoptysis, which lasted for a long time in some cases (up to 13th-15th day of illness).

There were clinical and roentgenological signs of pneumonia in 19 out of the 25 patients upon admission, starting on the 1st-2d day of illness. The signs of toxicosis, hyperthermia and involvement of the nervous system were more marked in expressly this group of patients.

In most cases, pneumonia was massive--confluent and focal (17 cases), bilateral (9). Intensive pleural pain (4), as well as development of pulmonary edema (13) were not uncommon in cases of development of pneumonia. In four cases the pneumonia was destructive-abscessing.

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Chief clinical symptoms of severe forms of influenza

Symptoms	Number of patients		Recoveries	Deaths
	absolute	%		
Acute onset	25	100	18	7
Headache	25	100	18	7
Vertigo	18	72	15	3
Vomiting, nausea	19	76	14	5
Delirium, seizures, unconsciousness	12	48	7	5
Cyanosis of mucosa and skin	25	100	18	7
Hemorrhages	16	64	10	6
Blood in sputum	9	36	7	2
Maximum temperature: 38.1-39°C	2	8	0	2
39.1-39.9°C	9	36	5	4
40°C and higher	14	56	13	1
Toxicosis, grade II	8	32	8	0
Toxicosis, grade III	17	68	10	7
Pneumonia:				
focal-confluent, polysegmented	17	68	11	6
focal	2	8	2	0
bilateral	9	36	6	3
abscessing	4	16	2	2
Complications:				
pleurisy	4	16	3	1
infectious-allergic myocarditis	3	12	3	0
respiratory insufficiency	21	84	15	6
acute cardiovascular insufficiency	6	24	5	1
pulmonary edema	13	52	10	3
cerebral edema	12	48	6	6
Concomitant diseases	11	44	5	6

Bacteriological examination of sputum revealed diverse microflora, including hemolytic staphylococcus (8 cases), streptococcus (4), pneumococcus (2), Friedlander's bacillus (1), E. coli (3), as well as fungi and yeast cells (4). All of the patients from whose sputum yeast cells and Candida fungi were isolated received antibiotics with a broad spectrum of action for a long time. With administration of antibacterials, there was sometimes a change of pathogen. However, it is known that investigation of the etiology of pneumonia by such conventional methods is not very informative (V. P. Sil'vestrov). For this reason, the results of serological tests on pairs of blood serum samples with the use of staphylococcal α -toxin were more conclusive. One-third of the patients presented a diagnostic increment of titer of antigen to staphylococcus (including 4 out of 6 cases with staphylococcus in sputum). This confirms once more the significant etiological role of staphylococcus in development of pneumonia with influenza, and this must be taken into consideration in deciding on the tactics of antibiotic therapy.

Repeated dynamic studies of acid-base parameters (AB) by the Astrup method in cases of influenza complicated by pneumonia revealed, in most cases, compensated metabolic acidosis and, in the more serious cases, decompensated metabolic

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acidosis. Acidosis persisted for a long time in patients with massive pneumonia. In spite of corrective therapy, normalization of AB parameters lagged 1-3 days behind appearance of clinical signs of resolution of pneumonia. Metabolic decompensated and respiratory acidosis was noted in the group of patients with serious concomitant pathology and cases of lethal outcome.

According to the results of EKG tests in the course of illness, during the period of marked toxicosis in cases of massive polysegmented pneumonia (17 patients), there was sinus tachycardia of up to 110-130/min and isolated atrial extrasystoles. At the height of toxicosis, elderly patients presented isolated and group ventricular extrasystoles. It should be noted that among elderly patients, in the group that expired, influenza was associated with chronic ischemic heart disease (4 cases), to which we can relate the frequency of complications in the form of ventricular extrasystole. Deviation of the electric axis of the heart to the right, appearance of either an increase in amplitude of R_{avR_1} , shift of transient zone of chest leads, decrease in amplitude of $S_{V_1V_2}$ wave and transient block of the right branch of the bundle of His (2 cases) should be interpreted as signs of overload on the right ventricle, which were observed in cases of the most massive pneumonia. As toxicosis diminished and pneumonia regressed, these EKG changes disappeared entirely.

In three young patients (15, 17 and 28 years old), the clinical manifestations and EKG changes--marked sinus tachycardia, dynamics of T waves--were evaluated as infectious-allergic myocarditis, which complicated the course of influenza and pneumonia. In two of these cases, clinical and EKG signs disappeared within 17-24 days, and in one (28 years old) the myocarditis became protracted.

Blood tests on complicated cases (3d-5th day of illness) revealed leukocytosis (up to 20,000-25,000) with marked left shift of the formula and elevated erythrocyte sedimentation rate. There was also a marked left shift of the formula in uncomplicated cases of influenza, at the early stage of illness.

One of the distinctions of this epidemic was that the toxicosis, with high fever and circulatory disturbances inherent in influenza (Ye. S. Ketiladze), elicited in many cases signs of cerebral edema (12 people) and pulmonary edema (13), which were observed not only in the complicated cases, but in patients without complications referable to respiratory organs. It is known that new strains of influenza virus have very marked toxigenic properties, to which are related the severe signs of systemic toxicosis with circulatory disturbances, cerebral edema and extensive lesion to the epithelium of the respiratory tract (Ye. S. Ketiladze).

Analysis of the clinical symptoms of the patients under our observation revealed that the severity of influenza during this epidemic should be linked primarily with the influenza virus proper, rather than only the presence of complications. Expressly this can explain the development of such serious forms of influenza in young people, who presented no concomitant disease whatsoever.

The complicated cases of influenza received complex therapy aimed at different elements of the pathological process (V. F. Krylov; V. I. Pokrovskiy; Ye. S. Ketiladze et al., and others). Intravenous infusion of polyglucin, rheopolyglucin, hemodes, glucose solutions and dry plasma was used to control toxicosis. The tactics of treatment of toxicosis had the goal of infusing sufficient doses of fluids with strict monitoring of hourly positive diuresis. Special attention was

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given to dehydration therapy in cases of appearance of the edema syndrome-- cerebral edema, pulmonary edema. In such cases, therapy included intravenous injection of diuretics (lasix, furosemide, hyperosmotic mannitol solutions), as well as corticosteroids (prednisolone, hydrocortisone). In addition, when indicated in cases of development of pulmonary edema, fluid was aspirated from the respiratory tract and there were numerous sessions of breathing with a constantly elevated pressure of the air-oxygen mixture.

In cases of acute cardiovascular insufficiency, glycosides, mezaton, norepinephrine, large doses of prednisolone and hydrocortisone were used. When there was diminished contractile function of the myocardium, particularly among elderly patients with concomitant chronic disease, cardiac glycosides were prescribed. Complex therapy included expectorants and multiple vitamins; the patients also received antihistamines and desensitizing agents at the same time.

Treatment of inflammatory processes in the lungs occupied a special place. From the very first hours of hospitalization, at least two different antibiotics were ordered, with mandatory administration of one of them intravenously. Most often, intravenous injections of sodium penicillin (6-8 million units/day) with concurrent intramuscular injection of penicillin (4-6 active units) were given, which were combined with gentamycin, semisynthetic penicillin, tetraolean [sigmamyacin] and others. Because of the massive nature of pneumonia in most cases, at least 3-4 course of therapy were administered to achieve a therapeutic response, with successive alternation of antibiotics, using erythromycin (for intravenous injection), ceporin, [cephaloridine], lincomycin, tetraolean, metacycline, vibromycin, fusidin and others. Inhalation therapy occupied a large place in further treatment of pneumonia: DNAase, lysozyme, chymotrypsin. Inhalation therapy was instituted at the early stage of illness, after the patients were brought out of their extremely serious condition.

Considering the experience of the thoracic department at the Institute of Surgery imeni A. V. Vishnevskiy, USSR Academy of Medical Sciences, at the recommendation of A. M. Marshak, we used trichopol [flagyl] in average doses of 0.25, 3-4 times a day for 14-21 days, to suppress nongas-forming anerobic microorganisms in the focus of inflammation.

In most cases, there was slow regression of the inflammatory process in the lungs. Fever persisted for 3 to 20 days (average of 10.9 days). However, even with normalization of temperature, a cough persisted for a long time (12-28 days, average 21.8 days), with gradual change from suppurative to mucous sputum, after which it disappeared. The physical changes in the lungs persisted for 10 to 30 days (average 17.6 days). According to roentgenological examination, the inflammatory changes in lung tissue persisted for 3-5 weeks. In cases of abscessing and concomitant pleurisy (see Table), fever, pleural pain, physical and roentgenological changes in the lungs lasted 6-8 weeks.

In most cases, the outcome of illness was good. Seven patients expired, mainly among elderly individuals, including 4 who were 80-81 years old. There were serious concomitant diseases in 6 out of these 7 cases: chronic cardiac ischemia with cardiac decompensation (2 cases), chronic nonspecific lung disease (2), blood disease (1), severe diabetes with diabetic coma (in patients 65 years of age), with massive (destructive in 2 cases) pneumonia. As a rule, death was

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due to respiratory and cardiovascular insufficiency, pulmonary and cerebral edema. In four cases of late hospitalization, death occurred within the first 24 h.

Long-term follow-up was pursued for 3-5 months after discharge on 10 out of 18 convalescents. By this time, virtually all of them were fit for work. However, some of them periodically suffered from dull, pulling aches in the chest when breathing deeply. Physically, there was vesicular respiration (attenuated breathing in a 15-year-old female patient after abscessing pneumonia), without rales or pleural friction. Recheck x-rays revealed deformation of lung pattern and pleural superpositions only in cases of abscessing and pleurisy. AB test showed no deviation from normal. Signs of infectious-allergic myocarditis persisted clinically and according to EKG findings in one case (28 years old).

Thus, treatment of patients with severe, complicated form of influenza is a complicated and difficult task. There is worsening of the prognosis among elderly patients, particularly in the presence of concomitant chronic disease.

Influenza is often complicated by toxicosis, with development of pulmonary and cerebral edema, which determines the tactics of intensive therapy of this group of patients.

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INFORMATION STRUCTURE OF ONCOLOGICAL RESEARCH: STOCHASTIC ANALYSIS OF COMMUNICATION NETWORKS

Moscow MODELIROVANIYE I OPTIMIZATSIYA SLOZHNYKH SISTEM UPRAVLENIYA in Russian 1981 (signed to press 8 Jun 81) pp 188-195

[Article by L. I. Borodkin from book "Modeling and Optimization of Complex Control Systems", editor in chief Ya. Z. Tsyppin, corresponding member of the USSR Academy of Sciences, Izdatel'stvo "Nauka", 2350 copies, 271 pages]

[Text] Availability of information about structure, intensity and direction of communications between elements plays a substantial part in controlling any complex system. When considering oncology as a complex dynamic system, one usually singles out the information relations between scientific directions of this major scientific discipline as a decisive factor [1, 2].

Analysis of the structure of information relations in oncology and their quantitative characteristics becomes particularly important in solving a number of practical problems of optimum organization and control of research in this important branch of medicine. One of the most pressing problems of this type is to refine the planning of scientific research, particularly complex research; in this regard, it becomes necessary to also solve more special problems, for example, that of improving the supply of information to oncologists concerning the latest results obtained in allied areas of research.

A new approach was described [2, 3] to analysis of the structure of communication networks in oncology, which is based on the approximation method of aggregating empirical charts with many peaks [4], which permits presentation of the structure of relations between elements of a complex system in a compressed or enlarged form.

We propose here further development of this approach, which consists of using a probabilistic analogue of the approximation method of aggregating empirical charts [5] leading to broader opportunity of interpreting aggregation results. An algorithm is offered that executes the stochastic method of analyzing the structure of information relations in oncology, which is based on the use of this method.

1. Approximation method of aggregation of empirical charts (stochastic approach). Let $G(X, A)$ be a weighted "orgraph" [organization chart?], where X is the set of peaks specified by numbers $1, 2, \dots, n$; $A = \|a_{ij}\|_1^n$ is the matrix of arc weights. Let us specify that $Y = \{Y_1, \dots, Y_m\}$ is a set of "diffuse" units ["blocks"] ($m < n$). For each $i \in X$ let us also take into consideration a set of numbers $\{\phi_{iq}, q = \overline{1, m}\}$ characterizing the weight of reference of the i th peak of chart G to each of the m units $\{Y_q, q = \overline{1, m}\}$:

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$$\sum_{q=1}^m \varphi_{iq} = 1, \quad \varphi_{iq} \geq 0 \quad (q = \overline{1, m}), \text{ where } 1 \leq i \leq n. \quad (1)$$

Expressions (1) specify matrix $\Phi = \|\phi_{iq}\|$ $n \times m$ in size, the i th line of which can be interpreted as distribution of probabilities that element $i \in X$ belongs to each of units $\{Y_q, q = \overline{1, m}\}$. According to [4], we shall describe the strength of relation of each pair of units (Y_p, Y_q) by a certain number c_{pq} :

$$c_{pq} = \frac{\sum_{i,j=1}^n a_{ij} \varphi_{ip} \varphi_{jq}}{\sum_{i,j=1}^n \varphi_{ip} \varphi_{jq}} \quad (p, q = \overline{1, m}). \quad (2)$$

Let us approximate the initial chart $G(X, A)$ by means of chart $\hat{G}(X, \hat{A})$, where

$$\hat{A} = \Phi \Phi^T \quad (3)$$

Then the stochastic approach to aggregation of weighted charts is formalized as the following extremal problem:

$$\min_{\Phi \in \mathcal{F}} \|A - \Phi \Phi^T\|, \quad (4)$$

where \mathcal{F} is the set of matrices Φ $n \times m$ in size, determined in accordance with (1). With consideration of formulas (2) and (3), problem (4) is reduced to minimization in set \mathcal{F} of the functional:

$$J = \sum_{k,j=1}^n \left[a_{kj} - \sum_{p,q=1}^m \varphi_{kp} \varphi_{jq} \left(\frac{\sum_{r,i=1}^n a_{ri} \varphi_{rp} \varphi_{iq}}{\sum_{r,i=1}^n \varphi_{rp} \varphi_{iq}} \right) \right]^2. \quad (5)$$

Thus, problem (4) is a problem of nonlinear programming with restrictions (1); functional $J(\Phi)$ in general is not convex. The algorithm of minimization of functional (5) on set (1) is described below.

2. Algorithm of stochastic aggregation of empirical charts. The substantial distinction of extremal problem (4) is that the restrictions (1) are "separable": the permissible range of \mathcal{F} specified in the $(n \times m)$ -dimensional space of variables $\{\varphi_{ip}, i = \overline{1, n}; p = \overline{1, m}\}$ is the direct product of $\mathcal{F} = S^1 \times S^2 \times \dots \times S^n$ m -dimensional simplexes:

$$S^i = \left\{ \varphi^i = (\varphi_{i1}, \dots, \varphi_{im}) \mid \varphi^i \geq 0, \sum_{p=1}^m \varphi_{ip} = 1 \right\}, \quad i = \overline{1, n}.$$

This structural feature of problem (4) enables us to turn to the general scheme of the iterative algorithm of local minimization of functional (5), at each iteration of which there is minimization of functional (5) on a set of elements of only one

*Stochastic interpretation of elements of matrix $C = \|c_{pq}\|_1^m$ is given in [5].

line of matrix Φ with fixed values of elements of the other $n - 1$ lines. Thus, in solving each such special problem, variations of functional J depend only on variations of elements $\{\phi_{ip}, p = \overline{1, m}\}$ in the i th line being modified (and the permissible range is simplex S^i).

Proceeding from this, let us write out formula (5) isolating in overt form functional J as a function of elements $\{\phi_{ip}, p = \overline{1, m}\}$:

$$\begin{aligned}
 J(\phi^i) = & \sum_{k, j \neq i} \left(a_{kj} - \sum_{p, q=1}^m \varphi_{kp} \varphi_{jq} c_{pq} \right)^2 + \\
 & + \sum_{k \neq i} \left[\left(a_{ik} - \sum_{p, q=1}^m \varphi_{ip} \varphi_{kq} c_{pq} + \left(a_{ki} - \sum_{p, q=1}^m \varphi_{kp} \varphi_{iq} c_{pq} \right) \right) + \right. \\
 & \left. + \left(a_{ii} - \sum_{p, q=1}^m \varphi_{ip} \varphi_{iq} c_{pq} \right) \right], \\
 c_{pq} = & \left[\sum_{k, l \neq i} \varphi_{kp} \varphi_{lq} a_{kl} + \sum_{k \neq i} (\varphi_{ip} \varphi_{kq} a_{ik} + \varphi_{kp} \varphi_{iq} a_{ki}) + \right. \\
 & \left. + \varphi_{ip} \varphi_{iq} a_{ii} \right] / \left[\left(\sum_{k \neq i} \varphi_{kp} + \varphi_{ip} \right) \left(\sum_{l \neq i} \varphi_{lq} + \varphi_{iq} \right) \right].
 \end{aligned} \tag{6}$$

We shall submit functional (6) to minimization in set S^i by means of an iterative nonprojection algorithm based on the simple procedure of going on to the next iteration, which assures movement in the permissible range (simplex S^i).

This procedure of modifying a point on the simplex (analogous to the one proposed in [6]) shifts any point $\phi^i = (\phi_{i1}, \dots, \phi_{im}) \in S^i$ to another point $\tilde{\phi}^i = (\tilde{\phi}_{i1}, \dots, \tilde{\phi}_{im}) \in S^i$:

$$\tilde{\phi}_{ir} = \varphi_{ir}(1 - \alpha) + \alpha, \quad \tilde{\phi}_{ip} = \varphi_{ip}(1 - \alpha), \quad p \neq r, \tag{7}$$

where $1 \leq r \leq m$, α is a parameter of procedure ($0 < \alpha \leq 1$), and the smaller the value of α , the closer point $\tilde{\phi}^i$ is to point ϕ^i (with $\alpha \rightarrow 0$ $\tilde{\phi}^i \rightarrow \phi^i$).

Thus procedure (7) modifies point $\phi^i \in S^i$ by increasing the value of the r th component of ϕ_{ir} by means of reducing the values of the other $m - 1$ components of ϕ_{ip} ($p \neq r$). Let us designate point $\tilde{\phi}^i$, which was obtained in accordance with procedure (7) with a certain fixed r , in the following manner: $\tilde{\phi}^i = D_r \phi^i$.

Thus, let there be a given initial matrix $\Phi(0) \in \mathcal{F}$.

Algorithm 1. Minimization of functional $J(\phi^i)$ on set S^i .

1. Let us assume $t = 0$. We calculate $J(\phi^i)$ using formula (6).
2. Let us assume $\alpha(t) = 1/(t + 1)$.
3. We apply procedure (7) to point $\phi^i(t)$, changing the value of index r from 1 to m and calculating each time:
 $\Delta_r J(\varphi^i(t)) = J(D_r \varphi^i(t)) - J(\varphi^i(t)).$
4. We determine the value of
 $\Delta_r J(\varphi^i(t)) = \min \{ \Delta_r J(\varphi^i(t)) \}.$

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5. If $\Delta_s J(\varphi^i(t)) \geq 0$, we assume $\varphi^i(t+1) = \varphi^i(t)$; we go on to paragraph 7.

6. If $\Delta_s J(\varphi^i(t)) < 0$, let us assume

$$\varphi_{is}(t+1) = \varphi_{is}(t)(1 - \alpha(t)) + \alpha(t),$$

$$\varphi_{ip}(t+1) = \varphi_{ip}(t)(1 - \alpha(t)), \quad p \neq s.$$

7. Let us increase the value of t by 1 and go to paragraph 2.

The properties of convergence of this algorithm are established with the following theorem.

Theorem: If $\{\phi^i(t)\}$ is a sequence constructed by algorithm 1, each of its limit points belongs to the set $T^i \in S^i$ of points, for which the necessary conditions of minimum functional $J(\phi)$ on simplex S^i have been satisfied.

To run algorithm 1, it is necessary to set the condition for stopping it. Let us stop operation of the algorithm if, when plotting the next point $\phi^i(t)$ the specified precision of δ has been achieved, i.e.,

$$\|\varphi^i(t) - \varphi^i(t-1)\| \leq \delta. \quad (8)$$

Let us note that the scheme of constructing the above-described algorithm one enables us to classify it with algorithms of the method of possible directions [7]; unlike known algorithms of this method, ours does not require solution at each step of the extremal problems to determine the direction and magnitude of the next step, which renders it quite simple to run.

On the basis of algorithm 1, which is used for minimization of functional J on a set of elements of one line of matrix Φ , we can construct the general algorithm to search for the approximate solution of the problem of aggregation of charts with diffuse units (4), the permissible range of which is the set of all elements of matrix Φ with limitations (1).

The algorithm is an iterative procedure with cyclic repetition of the sequence of lines in matrix Φ .

We start the search by specifying an arbitrary matrix $\Phi(0) \in \mathcal{C}$ and a certain number $\delta > 0$.

We use algorithm 1 in the k th iteration for minimization of functional J on the set of elements of the next line of matrix $\Phi(k-1)$ (algorithm 1 is stopped by satisfying condition (8)).

3. Analysis of the structure of information relations in oncology. In this section we describe the results of using the above stochastic method of aggregation of empirical charts to solve the problem of singling out the major directions of research in oncology and determining the structure of information relations between them. And, as in [3], the chart of citations, the peaks of which consisted of over 1600 publications dealing with oncology, which were selected by experts from the Oncological Research Center of the

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USSR Academy of Medical Sciences,* was used as primary information. Subsequent work was done on the basis of the classifier of the most important topics of oncological research, which was compiled by the Scientific Council for the Problem of "Malignant Neoplasms" under the Presidium of the USSR Academy of Medical Sciences. This classifier has two levels, the first of which consists of 13 medical directions (problems):

1. Biology and biochemistry of the neoplastic cell
2. Viral carcinogenesis
3. Chemical carcinogenesis
4. Radiation carcinogenesis
5. Immunology of tumors
6. Relationship between tumor and organism
7. Tumor morphology
8. Diagnosis of malignant tumors
9. Experimental and clinical chemotherapy
10. Surgical management
11. Radiobiology and radiotherapy
12. Epidemiology of malignant tumors
13. Scientific bases for organizing cancer control

Each of these problems consists of several topics (total of 121), which form the second level of the classifier.

Using this classifier and the initial citation chart we plotted chart G', which characterizes the intensity of citation (number of peaks on chart G' is 13). The weight of each arc (i, j) of this chart equals the number of references in works dealing with the i th problem to works dealing with the j th problem.

As in [3], we aggregated chart G' to the level of four units.** In this case, the units are "diffuse" and stochastic [probabilistic], so that it is possible, on the one hand, to demonstrate the "nucleus" of directions determining the content of each unit and, on the other hand, to define the role of each direction in each of the units. This approach is expedient because of the complex, interdisciplinary nature of scientific directions that make up the content of a dynamic field such as oncology.

Table 1 illustrates matrix Φ^* of weights of reference of the indicated scientific oncological directions to the four units that were singled out (the matrix is constructed by means of the described algorithm; $\delta = 0.01$), and Table 2 shows matrix C of interunit relations. As can be seen in Table 1, only 5 of the 13 directions are contained in only one of the units, whereas the other 8 are "diffused" in 2-3 units (this applies particularly to the "chemical carcinogenesis" and "chemotherapy of tumors" directions).

*Let us note that analysis of citation nets is, along with expert evaluation methods, the main method of demonstrating the structure of relations in modern science [1, 8].

The method of forming citation charts in oncology is described in [3].

**The structure of relations between units was so given as to have one of the units (the fourth) isolated, i.e., the weight of reference of each peak of chart G' to this unit should characterize the degree of information-related isolation of the corresponding scientific direction.

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Table 1.

Unit No	Direction number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
I	1,0	0,00	0,06	0,00	1,0	0,00	0,00	0,00	0,18	0,00	0,00	0,00	0,00
II	0,00	1,0	0,74	0,00	0,00	0,67	1,0	0,00	0,08	0,00	0,00	0,00	0,00
III	0,00	0,00	0,20	0,49	0,00	0,33	0,00	0,64	0,74	0,28	0,75	1,0	0,80
IV	0,00	0,00	0,00	0,51	0,00	0,00	0,00	0,36	0,00	0,72	0,25	0,00	0,20

Table 2.

Unit No	Value of inter-unit relation			
	I	II	III	IV
I	3,05	2,82	1,68	0,75
II	7,48	1,76	1,48	0,77
III	1,89	0,81	0,95	0,50
IV	0,94	0,38	0,38	0,11

To interpret the results contained in Table 1, let us set number ρ as the "threshold of significance" of weights $\{\phi_{op}\}$. Let, for example, $\rho = 0.5$. Then directions 4 (radiation carcinogenesis) and 10 (surgical management of tumors) can be considered isolated with regard to information in the overall system of relations in oncology.* The aggregated structure of flow of information between oncological directions, constructed with consideration of the chosen threshold of significance according to data in Tables 1 and 2, contains 3 units. "Viral carcinogenesis," "chemical carcinogenesis," "relations between tumor and organism" and "morphology of tumors" directions are referable to unit A. The directions of "diagnosis of malignant tumors," "experimental and clinical chemotherapy," radiobiology and radiation therapy," "epidemiology of malignant tumors" and "scientific bases for organizing cancer control" belong to unit B. The directions in unit C--"biology and biochemistry of the cell" and "immunology of tumors"--play a central role in the structure of information; these directions, between which there is active exchange of information, are also the "suppliers" of information for the directions in unit B (which could be arbitrary called clinical practice and experimentation) and unit A (theoretical research). These two directions of unit C are consumers of information supplied by the directions of unit A.

The nucleus [core] of unit A (Table 1) consists of directions 2 (viral carcinogenesis) and 7 (tumor morphology); that of unit B is formed by directions 12 (epidemiology of tumors) and 13 (scientific bases for organizing cancer control).

The weight of reference of direction 3 (chemical carcinogenesis) to unit A of theoretical research is more than twice its weight of reference to unit B of

*The isolation of unit IV is distinctly illustrated by the appearance of the matrix of interunit relations C (Table 2).

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applied research; the weight of reference of chemotherapy of tumors (9) to unit B is 4 times greater than the weight of reference of this direction to unit C, etc.

In addition to directions 4 and 10, directions 8 (diagnosis of malignant tumors), 11 (radiobiology and radiotherapy) and 13 (scientific bases for organizing cancer control) are also characterized by some degree of information-related isolation.

In conclusion of this analysis, let us note that the results of stochastic aggregation of the information structure of oncology, which generally conforms with previous conclusions as to the nature of this structure [2, 3], not only defines and enlarges upon them, but leads to a number of new conclusions.

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PHYSIOLOGY

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PHYSIOLOGICAL AND BEHAVIORAL GENETICS

Leningrad FIZIOLOGICHESKAYA GENETIKA I GENETIKA POVEDENIYA in Russian 1981 (signed to press 6 Apr 81) pp 2-5, 356-358

[Annotation, introduction and table of contents from book "Physiological Genetics and Behavioral Genetics", edited by L. V. Krushinskiy, in "Manual of Physiology" series, Izdatel'stvo "Nauka", 5050 copies, 359 pages]

[Text] This book deals with current problems of genetics of behavior and physiological characters. It reports the results of studies conducted on various objects, ranging from protozoans to man. Considerable attention is devoted to research methods on the molecular, cellular, organismic and population levels. A special place is reserved for the principles of genetic analysis of behavior. There is rather full coverage of questions of genetic determination of behavior, genetic control of neurohormonal distinctions and the learning process. The role of behavior is disclosed in the process of evolution. The applied value of genetic approaches is demonstrated with respect to monitoring the behavior of farm animals. There is discussion of inheritance of pathological psychological and behavioral changes in man. Unsolved problems of neurogenetics are mentioned and means of working on them are indicated. References 1023, figures 41, tables 30.

Introduction

Significant progress in various branches of physiology, ethology, genetics, biochemistry and psychiatry is to be credited for the conception and intensive development at the present time of behavioral genetics as a science. This discipline has achieved major success and was transformed into a broad interdisciplinary branch of knowledge in the 2 decades that have elapsed since the first monograph by J. Fuller and W. Thompson, "Behavior Genetics" (1960), was published. The approaches and methods used to study the role of hereditary factors in formation of animal behavior are being used more and more often each year in agricultural and medical practice, in physiology and psychiatry.

The decree adopted by the CC CPSU and USSR Council of Ministers, "On Measures to Expedite Development of Molecular Biology and Molecular Genetics, and Use the Achievements Thereof in the National Economy," opened up broad opportunities for development of research in genetics of behavior and physiological processes. However, the lack of a manual on methodology and problems of behavioral genetics, in the Soviet educational literature, that would be available to all, is making it difficult for this discipline to grow in our country. The book offered to the

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reader, which was written by a team of prominent Soviet specialists in the field of behavior genetics is an attempt to fill this gap.

It is not by chance that "Physiological and Behavioral Genetics" was included in the multivolume "Manual of Physiology" series, and its publication is timely. For genetics is not only a science that deals with heredity; an equally important task is to study the mechanisms and patterns of occurrence of intraspecific variability, the existence of which causes considerable difficulties in analyzing and interpreting results of physiological experiments. Genetics can and must resolve and explain the causes of this variability.

This textbook is constructed in two sections. The first deals with general questions of behavioral genetics, principles of genetic analysis of behavior and offers an idea about the special mathematical methods of processing research results. In this same part is described the current status of a number of pressing problems of biochemical phenogenetics and neuroendocrine mechanisms of regulation of genetic and cytogenetic processes. The second section deals with more special problems of behavior genetics: problems of learning and inheritance of pathological forms of behavior and, in particular, epilepsy and schizophrenia. A special distinction is made of problems of farm animal behavioral genetics and the problem of microevolutionary role of behavior.

This manual begins with a chapter on the current status of genetics of behavior and physiological processes. Its author, L. V. Krushinskiy, is a well-known Soviet physiologist and geneticist; on the example of studies conducted with different objects, he demonstrates the role of genotype and environment in formation of a number of physiological and behavioral characters. The second chapter (written by L. Z. Kaydanov and Ye. M. Luchnikova) deals with the principles of genetic analysis of behavior, mainly in the *Drosophila*. The area of application, advantages and disadvantages of the main methods of genetic analysis--mutation, comparative genetic and breeding--are submitted to a comprehensive critical examination. Analysis of correlations between behavioral, physiological and biochemical characters, which was made on genetically well-known material, may be of special interest from the physiologist's point of view. In the next chapter (author--P. M. Borodin) there is a comprehensive discussion of the bases for planning diallele experiments and interpreting their results. Special attention is given to the most common mistakes in using this relatively new method of physiological experimentation, which could be used for both the study of degree of genetic determination of a character and investigation of architectonics of the genotype and separation of behavior and several physiological functions into elementary components.

The next two chapters (authored by L. I. Korochkin and N. G. Kamyshev, Ye. V. Savvateyeva, V. V. Ponomarenko) describes one of the promising directions of developmental genetics, which investigates the effect of the genome on a character from the standpoint of analysis of nuclear and cytoplasmic relations (Chapter 4) or neuroendocrine regulation of differential activity of the genetic system on the transcription level (Chapter 5).

Chapter 6 (by L. N. Trut) deals with the current status of problems of genetics of learning and consolidation of memory. The data obtained by means of hybridological analysis indicate that the nature of inheritance of the main parameters

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of learning depends on the genotypic environment in which a given character is studied. The author describes in detail a new analytical method which involves the study of the nature of distribution of a character in a series of recombinant lines.

Studies in the field of genetic etiology of diseases of the nervous system and elaboration of methods for early detection thereof is the topic of Chapter 7 (by L. G. Romanova and L. G. Kalmykova), and considerable attention is devoted to questions of pathophysiology of higher nervous activity in man and the house mouse. Chapter 9 deals with the genetic aspects of farm animal behavior (written by L. A. Alekseyevich), which are related to analysis of adaptation when kept in industrial complexes, determination of the nature of inheritance of a number of behavioral characters and breeding animals with specific economically useful behavioral traits.

The last chapter, "Animal Behavior as a Factor in the Process of Microevolution" (by L. V. Krushinskiy and I. I. Poletayeva), occupies a special place in this manual. The material in this chapter reflects the population-species approach to the study of genetic behavioral distinctions of animals, and it is the most comprehensive work on this subject in the Soviet literature. According to the submitted data, the behavior of an individual [specimen] may determine the nature of microevolutionary transformations in animal communities, while the breeding value of a given phenotype (genotype) depends largely on the specific genetic environment that thus affects formation of behavior. The latter factor is usually underestimated in physiological experiments.

All of the foregoing warrants the opinion that publication of this volume was needed by a wide circle of specialists studying physiology and genetics of behavior in different sectors of the national economy.

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RECOGNITION AND CODING

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[Annotation, foreword by B. F. Lomov, corresponding member of the USSR Academy of Sciences, introduction, bibliography and table of contents from book "Recognition and Coding", by Tat'yana Petrovna Zinchenko, published by decree of the editorial and publishing council of Leningrad University, Izdatel'stvo Leningradskogo universiteta, 3000 copies, 183 pages, 38 figures, 26 tables, 199 bibliographic items]

[Text] This monograph submits the results of experimental studies conducted by the author of operator performance in the modes of identification, recognition, decoding and information retrieval when working with different code alphabets. An effort was made to submit the recognition process to systems and structural analysis. There is discussion of the place of recognition in the system of other forms of cognitive activity. The recognition process is viewed as having many levels. Investigation is made of the different operations making up the recognition process and functional structures that express them. There is formulation of ergonomic principles of building and evaluating systems of coding visual and auditory information. This book is intended for specialists in the fields of ergonomics, engineering and experimental psychology and engineers. It may also be useful to psychologist-students in different specialties.

Foreword

To the bright memory of Petr Ivanovich Zinchenko

The monograph by T. P. Zinchenko constitutes a fundamental, theoretical and experimental investigation of the recognition process, which was conducted by the author and her colleagues over a period of several years. It deals comprehensively with recognition as a special process; its macrostructure and microstructure are analyzed, as well as the place of recognition in the system of other mental processes. This distinguishes the monograph to advantage from other publications (which are very few in number) on the same subject that are available in the Soviet literature.

The author explores recognition as a process with complex and multilevel structure. For this reason, the methodology of systems analysis is applied with good justification to this study. This makes it possible to undertake development

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of psychological recognition theory. It is to the credit of this book that there is a combination of different research levels: psychophysical, psychophysiological, microstructural, engineering psychology. The author also draws upon material referable to pathology of the peripheral branch of the visual analyzer.

The first chapter of the book deals with the place of recognition in the system of other cognitive processes: perceptive, mnemonic, thinking, etc. The second chapter merits special attention; it provides the structural and functional characteristics of the recognition process. Recognition is explored in detail for the first time as a multisystemic process, which contains perceptive, selective and mnemonic elements.

The use of different methodological approaches and diversified investigative methods yielded new data, which characterize not only the psychological mechanisms of recognition, but the microstructure of attention in the recognition process. Of special interest are the general patterns demonstrated by the author with regard to reception and processing of visual and auditory multidimensional signals.

A complete and integral description of the recognition process is obtained in the monograph of T. P. Zinchenko by virtue of the fact that recognition is considered not only as an independent process, but as part of processes of decoding, information retrieval and preparation of decision.

The third chapter has an overtly practical orientation. It is concerned with development of psychological principles of coding visual and auditory information. The results of her investigations enabled the author to formulate the main requirements for coding information, which must be taken into consideration by engineering psychologists and designers, who develop the means of displaying information.

This book has an abundance of experimental data obtained on the basis of a number of original investigative methods. The experimental facts logically ensue from the author's theoretical constructions. In all instances, there is distinct presentation of the hypothesis of the study, discussion and analysis of other possible hypotheses and assumptions. This is indicative of the unity of conception of the extensive and original cycle of studies of recognition.

I am convinced that the book of T. P. Zinchenko, which constitutes a substantial contribution to development of psychological theory of recognition, will be welcomed by readers with interest.

Introduction

The problem of perception and recognition is among the most important ones in psychology. Direct, sensory reflection of reality is the foundation for forming abstract thought processes. At the same time, development of sensory processes is of substantial importance to improvement of a subject's practical endeavors since, as indicated already by I. M. Sechenov, "all purposeful actions are regulated by sensations." At the present stage of development of technology, sensory processes play as important a role in human endeavor as thinking processes. As validly noted by B. G. Anan'yev, "the most far-reaching advances of science and technology are intended not only for thinking, but for feeling man."

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The recognition process has been drawing much attention on the part of researchers in recent years. Since the recognition process is one of the main mental processes, it is of definite theoretical interest to study it. On the other hand, the study of recognition also has practical implications. The scientific and technological revolution has led to development of new forms of labor. At the present time, recognition really exists as a specific form of labor (for example, operator-observer). This compels us to raise the question of demonstrating the structure of recognition. It is imperative to take into consideration the patterns and mechanisms of the recognition process when solving problems of coding and displaying information on indicator equipment.

Since information about a controlled object in modern control systems is transmitted in coded form, optimum coding of incoming information is one of the chief means of assuring operational performance of man in the system, which also means efficiency of operation of the entire system. The importance of working on the problem of optimum coding is determined by the fact that the chosen symbols have a direct effect on the speed and precision of receiving and processing information by an operator. Moreover, the coding methods that are used affect the reliability and cost of information display equipment, since they determine the type of indicator equipment.

We construe code (according to the definition adopted in communication theory) as a system of correspondences between elements of communications and combinations of signals by which these elements are expressed. Optimality of a code implies that it provides for maximum speed and reliability of reception and processing of information by man. In the most general form, an optimum code is one that is developed in accordance with the patterns of processes of reception and processing of organization, in the organization of which it participates. For this reason, the solution of the problem of optimum coding is closely linked to investigation of reception and processing of information by man.

Investigation of the psychological mechanisms and structure of operator performance has occupied in recent years a central place in elaboration of theory of engineering psychology. And, as indicated by B. F. Lomov [1], the specifics of research in engineering psychology require investigation of how machines mediate this activity, which includes processes of forming an image of control objects and their states, comparison of incoming signals, retrieval of information from memory, decision making, programming actions, evaluating results, etc.

The activities of an operator dealing with reception and processing of submitted information include various operations: detection of signals, comparison thereof to standards written in memory and recognition, decoding, etc. The recognition process is an important element of this activity.

Our objective here was to investigate the psychological patterns of the recognition process. Recognition can be defined as a process of relating directly perceived ambient reality to perceptual and verbal standards recorded in the individual's memory. The recognition process has a complex, multi-level structure. For this reason, we considered it useful to draw upon the methodology of systems analysis to investigate recognition.

The systems approach implies that it is necessary to consider the phenomenon under study from different angles. In the first place, it is a phenomenon on its own.

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In the second place, it is a phenomenon that is considered in a specific system and is subject to its laws. In the third place, the synthetic aspect of studying the phenomenon implies that it must be considered as the product of the entire set of existing conditions, endogenous and exogenous [2].

Proceeding from the above principles, we believe performance of systems analysis of the recognition process should proceed in the following main directions.

1. Consideration of the place of recognition in the system of other cognitive processes.
2. Examination of the functional structure of the recognition process.
3. Investigation of recognition as a multisystem process, containing perceptive, selective and mnemonic elements.
4. Demonstration of important factors determining the structure, content and effectiveness of the recognition process, investigation of these factors from the standpoint of the nature of their influence on the recognition process and determination of the quantitative patterns of this influence.
5. Finally, in the system of cognitive processes, recognition may emerge not only as an independent activity, but as a special action that provides for reaching an interim result. In this regard, it is necessary to analyze the place of recognition in reception and processing of information and to investigate the recognition process as an element of activity in the modes of decoding, information retrieval and informational preparation of decision.

One of the general requirements for systems analysis of mental phenomena is that different levels of investigation must be combined. In our book, the recognition process is studied in different aspects: psychophysical (determination of threshold characteristics for different perceptive categories); psychophysiological (in order to study coordination of functional systems implementing the recognition process); microgenetic (which discloses the distinctions of perceptive categories at different stages of the recognition process); microstructural (analysis of structural organization of operations involved in reception and processing of information); use of data on pathology which, as indicated by A. R. Luriya, "makes it possible to break the perceptive process down into elements and examine expressly what in the perceptive process depends on a given element"; engineering psychology (study of effectiveness of reception and processing of information as related to the problem of coding and displaying information on display equipment).

As stimulus material, we used in our studies different alphabets, which are used to develop information models: alphabetic, digital, alphabets of conventional signs, one- and multi-dimensional alphabets made up by combining categories of shape, size, orientation, color and brightness of an object, etc.

Since coding of incoming information is performed chiefly by means of visual signals in real control systems, investigation of reception and processing of visual information occupies the main place in this monograph. However, considering the advantages of an acoustical signal, such as the wide range of frequencies and intensities, relative independence of spatial position, considerable imperviousness to interference, which make it preferable in a number of situations, we also

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investigated the patterns of recognition of audio signals, as related to the problem of coding auditory information.

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PSYCHOLOGY

COURSE OF ENGINEERING PSYCHOLOGY

Tallinn KURS INZHENERNOY PSIKHOLOGII in Russian 1978 (signed to press 8 Dec 78)
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[Annotation, foreword, conclusion and table of contents from book "Course of Engineering Psychology", by Mikhail Arkad'yevich Kotik, designed by V. Yershov; 2d edition, revised and enlarged, Izdatel'stvo "Valgus", 25,000 copies, 364 pages, illustrated]

[Text] This book is a substantially revised and enlarged edition of the previously published "Brief Course of Engineering Psychology" (Tallin, 1971). It is based on the course of lectures on engineering psychology delivered at the Tartu State University for the last 10 years. This book is intended for students in the psychology department of universities and technical VUZ's studying this course. It may be useful to specialists in the fields of psychology, ergonomics, cybernetics and others, who are concerned with investigation, planning and practical use of man-machine systems.

Foreword

In the last few years, questions of engineering psychology have acquired much importance, not only in psychology, but to some extent as the decisive factor in development of technology. Experience has shown that technology, which is the tool of human labor, can yield the required results only if it is properly coordinated with man's psychophysiological capabilities. For this reason it is practical necessity that determined the interest in engineering psychology, a science that is called upon to provide for such coordination: without using the knowledge in this field it has become impossible to develop complex control systems that would meet current requirements.

Scientific research institutes and laboratories are seriously involved with problems of engineering psychology; they are also taken into consideration by planning and designing organizations in development of man-machine systems, as well as those who operate them. All these circumstances made it necessary to train specialists in engineering psychology and to teach this discipline in technical VUZ's. A need arose for textbooks and manuals dealing with a course of engineering psychology.

In 1969, we published a textbook, "Fundamentals of Engineering Psychology," which was intended for students in the psychology department of Tartu Universitii, and in 1971 we published the "Brief Course of Engineering Psychology." The present book is a substantially revised and somewhat enlarged version of this course. In the interim years there have been many new studies in the field of engineering

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psychology and a number of new books were published covering its different aspects; All-Union standards were published, which regulated the terminology of engineering psychology and different aspects of designing man-machine systems. All these data were taken into consideration in the new edition of this course.

In our presentation, we tried to depart from the laboratory and fragmentary approach to analysis of mental processes, which is partially inherent in experimental psychology and extrapolated to engineering psychology. Theory of object-related activity, which is being successfully developed by Soviet psychological science, was the theoretical foundation of this course. For this reason, the mental processes and characteristics of the human operator are discussed here, as much as possible, as they directly relate to his control-related tasks with due consideration of the goals and conditions of work, emotional manifestations generated by it and self-regulation processes. The distinctions of operator activity proper--the specificity of goals that are set, clearcut definition of conditions and rigid limitations on the means of achieving them--are largely instrumental in using this approach in engineering psychology. As yet, there is no unified and conventional structure for describing the problems and questions that this discipline comprises. Some of its problems have not been sufficiently investigated, and there is no general agreement with regard to some of them. For this reason, in preparing this course, we tried to present, first of all, the issues that have already been defined, either theoretically or practically, as being the most relevant and for which there is a common point of view. The course also includes some less studied questions that we considered promising. We did not try to represent them as being solved and smooth over existing contradictions for the sake of an orderly presentation; we have submitted the actual state of affairs, voicing our attitude on this score without presuming to have definitive solutions. In a number of cases, we used the results of our research to prove our point of view.

Unlike other branches of psychological science, engineering psychology has one remarkable distinction. While it is usually enough for a psychologist to discover the pattern of mental activity, the data obtained in engineering psychology must also be advanced to a form that permits use thereof for making concrete practical decisions on the design or refinement of equipment, decisions pertaining to methods of operating it and training operators. It is necessary to express quantitatively many of the patterns demonstrated in the course of engineering psychological studies. In this regard, we have adhered to the following point of view in this course: the most important thing in engineering psychology is to demonstrate the mental patterns in operator performance, whereas formalization of these patterns is a secondary problem, for the solution of which the psychologist can call upon specialists in mathematics and engineering. For this reason, in presenting this course we concentrated chiefly on general principles, theoretical approaches to demonstration of the sought patterns, validation thereof, rather than a description of special algorithms of operator work, which are used to solve different control problems.

We were governed by our previous textbooks of engineering psychology, experience in delivering lectures on this subject at Tartu University for the last 10 years and the advice of our colleagues in selecting the structure of this course and order of presentation of material. Since the material presented in the "Course of Engineering Psychology" is based on some of the general theoretical theses of psychology, cybernetics, information theory, measurements, reliability, etc., the

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different chapters of this course begin with special overview paragraphs describing the theoretical bases of problems discussed in them, so that the material will be better understood by students of both psychology and engineering.

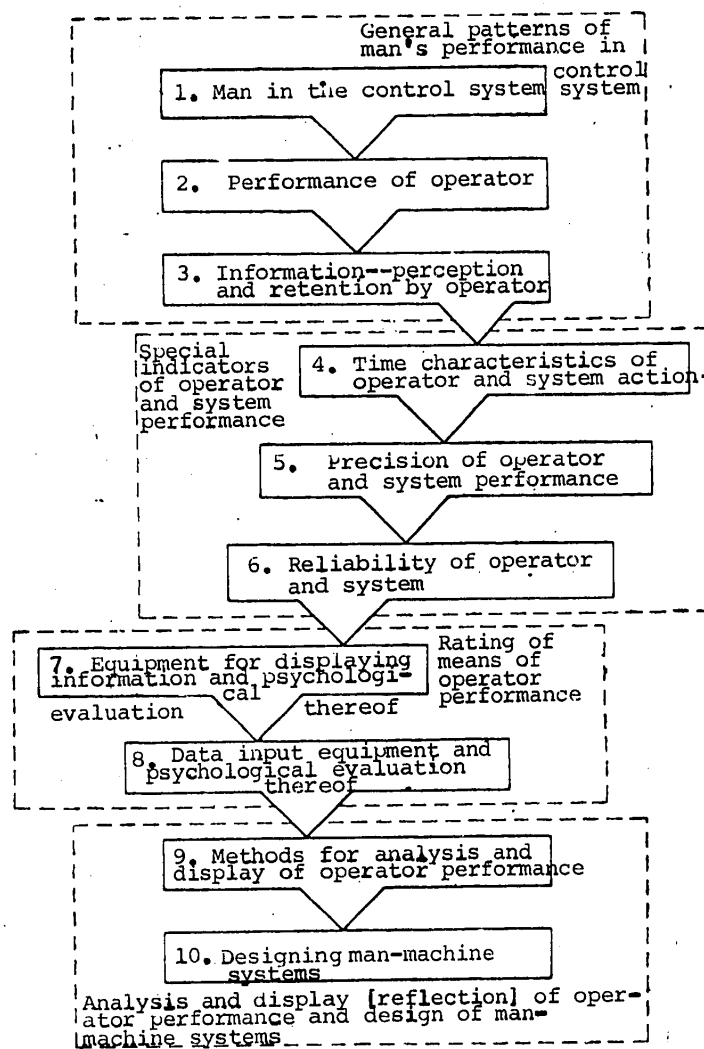


Figure 0.1. Block diagram of construction of course

For greater clarity, the order of presentation of educational material in this course is shown in the form of a block diagram (Figure 0.1). We see that there are four main sections. Chapters 1, 2 and 3 of the course deal with general patterns of man's performance in a control system. Chapters 4, 5 and 6 are concerned with different parameters [indicators] of operator and system performance. In chapters 7 and 8, there is analysis of the equipment with which the

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operator comes in direct contact from the standpoint of its psychological conformity to his performance. Chapters 9 and 10 discuss the use of the previously demonstrated patterns, characteristics and parameters of the operator and equipment to describe and analyze operator performance and to design [or plan] man-machine systems.

It should be noted that the main problems of engineering psychology singled out in this course do not cover all of the problems in this vast discipline. Because of the size restrictions, the course did not include questions of setting up experiments in engineering psychology, group operator performance, operator training or professional screening. All these questions are important in the field of engineering psychology, but expressly they had to be "sacrificed," since they are discussed in general form in other courses as well: experimental, social and pedagogic psychology and sections of industrial psychology. Incidentally, even if all of these problems had been covered in this course, it could still not be deemed full enough, since because of the youth of engineering psychology it is not deemed possible to clearly outline the range of problems that are contained in this field.

Conclusion

Thus, we have completed the presentation of the course of engineering psychology. As we look back and sum up, let us single out some of the most important theses that have run through all of the chapters of this course.

In presenting it, we tried to digress from the laboratory and fragmentary approach that has been established in engineering psychology to the study of operator performance, and to consider his different actions and different tasks related to his entire goal-oriented activities involving the use of equipment [technology] to reach the required results.

For this purpose, we used theory of object-related activity, which is the most consistent with the selected approach and enables us to analyze operator work and his interaction with the equipment he controls with consideration of both the goals of the operator, specified conditions and requirements of his performance, and human capabilities.

Such an approach was used in this course by means of singling out the range of exogenous--technical--restrictions (pertaining to promptness and precision of actions) on operator performance, the requirements and conditions of the task put to him, as well as the range of endogenous--psychophysiological--restrictions (referable to the same parameters), which ensue from man's individual capabilities. When mental processes and different parameters of operator performance are considered in connection with these restrictions, it is possible to submit this performance to systems analysis, taking into consideration man's characteristics and parameters of equipment, as well as the problems that man solves using this equipment.

Another important distinction of this course is that mental processes and parameters of operator performance are discussed with consideration of self-regulation. Previously, little attention had been given to this aspect of operator performance in the field of engineering psychology. For the sake of convenience of presentation and analysis of this range of problems, we arbitrarily singled out two areas

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of self-regulation: one based on energetic processes (ensuing from physiological changes in the body) and the other based on information processes. On the basis of theoretical theses, experiments and practical examples, it was shown that not only the area of information processes (which had been chiefly studied heretofore) but the area of energetic processes ensuing from emotional manifestations of the operator are important to engineering psychology. For this reason, much attention was given to these manifestations as well in this course. The concept of significance [relevance], which determined the operator's emotional reactions to different communications, actions, tasks, indicators and controls, runs through all of the chapters. The concept of significance, as it was shown, is not only a useful tool for psychological analysis, which makes it possible to relate the different actions of the operator to the problem he is solving, but a means of considering the subjective distinctions of the work studied and, which is quite important, its motivational aspect. It is of particular value to engineering psychology that this concept can be submitted to quantitative interpretation.

The next important idea that has pervaded the entire course is the thesis that investigation and evaluation of operator performance must be pursued not only from the standpoint of his potential capabilities, but with consideration of the fact that the operator does not always by far make use of these capabilities. It was shown that the route toward answering the question of the extent to which an operator will use his capacities to reach a specified goal lies on determination of the degree of significance to him of these goals and of the tasks related to achieving them. For this reason, investigation of the causes of delayed or inaccurate operator actions, causes of inadequate reliability or effectiveness of his work must be pursued not only by means of analysis of his information processes, but by means of determining the significance to a given operator of these actions and adequacy of these measures for actual conditions of working on the task.

In this course, considerable attention was devoted to questions of operator adaptation. It was shown that this feature is manifested on all levels of his mental activity in the control system. Thus, an operator adjusts to reception of incoming information, to processing it and performance of control actions on its basis, and this adjustment is fine and flexible on different levels and at different stages of each of these processes. As he gains experience, the operator's control actions are transformed into appropriate operations, and he acquires the ability to perform them instantly. It was shown that an operator also adapts to performing entire control tasks, and it is expressly on the basis of the requirements of these tasks (rather than the different characteristics of indicators or controls) that he organizes his performance--its speed and precision parameters--making use of information and energy reserves. It was also established that the human operator inherently adapts to the entire work performed, in accordance with individual capabilities and its external conditions, developing his own individual style. Moreover, an operator is found to be capable of successfully adjusting to disruption of working conditions and, like a truly "goal-oriented" system, he finds the optimum route for reaching his goal. Thus, the operator demonstrates a vivid tendency for purposeful adaptation to the equipment he controls and purposeful use thereof to reach a specified goal, in spite of occurring obstacles. This voluntary and involuntary adaptation of man to equipment encounters the tendency for adaptation of equipment to the capabilities and tasks of the operator, which is the essential objective of engineering psychology. Hence there is another important thesis: research and measures

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dealing with engineering psychology must take into consideration the operator's inherent tendency to adjust to equipment and to the tasks performed with the use thereof.

Such are the distinctions and main ideas of this book, to which we should like to call the reader's attention. Presentation of the subject of engineering psychology from the indicated points of view, in the form of a single organized system of knowledge, was the main objective of this course of instruction.

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USING HUMAN ENGINEERING TO IMPROVE OPERATOR PERFORMANCE

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 2, Feb 81 pp 30-40

[Article by B. F. Lomov, corresponding member, USSR Academy of Sciences: "Equipment Development and Problems of Psychology: A Scientific Report"]

[Text] Scientific and technological progress is leading to significant changes in industrial processes; there are also changes taking place in the conditions and nature of equipment operators' activities.

The most specific thing in the operators' performance is the fact that they are not able to directly observe the controlled processes: the operator works not with the actual objects but with models of them; information on the objects is transmitted in code using various devices. In order to carry out a particular control function, the operator must not only perceive the instrument signals but he must also decipher (decode) them. The signal decoding is, at times, an extremely difficult task whose accomplishment requires the expenditure of a rather large amount of time and a significant amount of mental stress from the operator.

The changes in the conditions and nature of the equipment operator's activities are such that he frequently has to work to the limit of his mental ability. This fact has a negative effect on equipment efficiency and reliability. As shown by an analysis of accidents which occur during equipment handling, the majority of them occur due to operator error. According to American statistics, this is the cause of about 70 percent of flying accidents, over 50 percent of the "malfunctions" of various types of equipment and over 60 percent of naval accidents.

The mistakes occur because the operator is not able to react to an unexpected signal in time, incorrectly perceives the signal, does not have time to shift his attention from one set to another, incorrectly deciphers the signal or acts by impulse under the effect of the high emotional strain. In other words, in many cases the causes of the mistakes are psychological in nature.

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Analysis shows that attention is one of man's most "delicate" mental functions; it "malfunctions" under the influence of very many factors.

Figure 1 shows the changes in the level of a subject's visual attention due to exposure to noise. Controlled measurements were made before the exposure to noise, immediately after the exposure, and 1/2, 1, and 2 hours after exposure. The size of the reduction in the subject's level of attention depended upon the intensity of the noise. The greater the intensity, the greater the reduction in the level of attention and the longer the time for restoring it. Let's make note of the fact that at moments of a decline in the level of the operator's attention, mistakes also appear in his work.

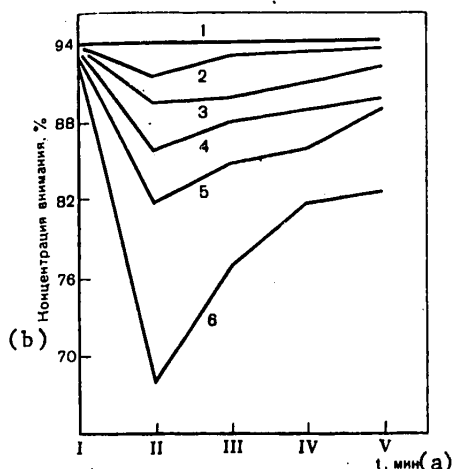


Figure 1. Noise's Effect on visual attention

Key:

Noise level:

1. Background (normal conditions)
2. 60 db
3. 70 db
4. 80 db
5. 90 db
6. 100 db

Time subject's attention measured:

- I. Prior to exposure to noise
- II. Immediately after exposure
- III. 30 minutes later
- IV. 60 minutes later
- V. 120 minutes later

- a. Time, in minutes
- b. Attention

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Naturally, the mistakes are made by the operator himself but sometimes it turns out that they are "provoked" by the equipment or the industrial process. Mistakes occur either because the information is transmitted in a form that is not suited to human perception, or because distracting signals appear during operations, or because a very high operating speed is required of the individual, etc.

When new equipment or a new industrial process is being developed, the designers unfortunately do not always think about how conditions will turn out for performance by the individual who will have to maintain or operate the equipment. Then, during equipment operations, it is discovered that it is "psychologically unsuitable" for the individual. Operation of it involves a great deal of "stress" on the operator's memory, perception or attention.

So, with the development of equipment, there arises the very complex (but very important) task of "integrating" it with human capabilities. The accomplishment of this task presupposes the examination of equipment operations and human performance in a single system (the "man-machine" system).

There are various ways of improving the effectiveness of "man-machine" systems reliability, ways which rely on the basic sciences. One of these ways is to consider human performance and abilities when new equipment is developed, in other words, matching the equipment and work conditions to the individual. In this case, it is necessary to have data on the principles of mental processes common to all people. Another is to select and train people for specific types of work. For this, it is necessary to have data on people's individual psychological differences, methods of determining these differences as well as a knowledge of training principles and characteristics. It should be pointed out that both of these ways do not exclude, but rather supplement, each other.

The task of finding ways of optimizing the match between equipment and the human operator's traits and abilities is directly related to three groups of psychological problems which are being studied by staff members of the USSR Academy of Sciences Institute of Psychology.

The first of these problems is the operator's receipt and processing of information. In its theoretical psychological aspect, this is a problem of perception, memory and thought.

The information required to monitor and operate equipment, as is well known, is transmitted to the operator by certain display systems in the form of an information model. The first requirement for the model is that it properly display the characteristics of the environment and the controlled objects. But, a human operator works with this model. This means that the model must be constructed in such a manner that it ensures timely and accurate perception of it.

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Therefore, while selecting a method for transmitting the information, it is necessary to know precisely how it will be perceived by man. In other words, it is necessary to consider the "chain": controlled entity--information model--operator perception of the model. The first link in this "chain" is a problem for the engineering sciences while the second is a problem for psychology. No matter how well the first link is designed, the efficiency and reliability of the entire system will be low if the second link "malfunctions." The bottom line for the entire system depends upon how well both links are matched with each other.

The information transmitted to the human operator, as is well known, is encoded using various values for certain physical values (sound, light, etc.). In developing a signal alphabet, it is frequently assumed that the physical (objective) values are directly and immediately reflected by the individual, that is, it is believed that the relationship between the objective and subjective values is a linear one. However, research shows that this is not so. The actual alphabet used by the individual to process information is formed on the basis of so-called subjective scales which are developed in the individual's head.

Research conducted at the Institute of Psychology on the subjective scaling processes has shown that the subjective scales are different when the individual accomplishes different tasks. The scales are signal discrimination, categorization and evaluation scales. Moreover, while the discrimination scales bear a logarithmic relationship to signal size, the categorization and evaluation scales bear an exponential relationship (the exponents are different for signals of different modalities). When a physical alphabet of signals is being developed, it is important to know what subjective scales an individual will use to perceive them.

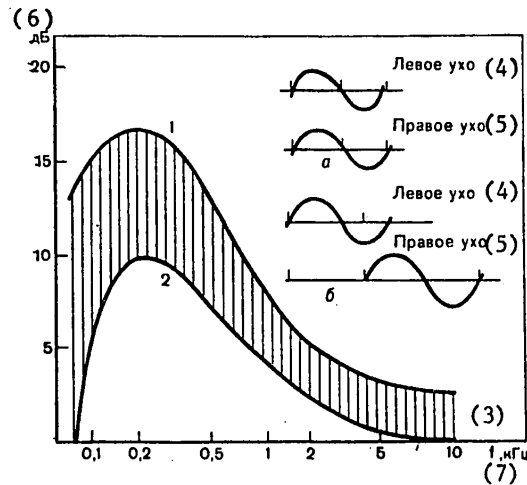
One of the operator's difficult jobs is the one whose performance requires him to receive weak signals which, on top of being weak, appear against background noise. In this case, when working in the "threshold area" (at the boundary of human perceptual ability), part of the signals are detected by the operator while part are missed; in some cases, there are false alarms: there was no signal, only noise, but it seemed to the operator that there was a signal.

The Institute of Psychology's research on operator detection of weak sounds against background noise has revealed a definite relationship between signal detection threshold and frequency. This research has also uncovered several possibilities for improving the detection of weak sounds by using the operating principles of the sensory systems (Figure 2).

One of the general principles of the perceptual processes and related attention is that their level varies over time. At some instants, attention increases; at others, it declines. These variations are quasi-periodic in nature with a 20-30 minute interval and are related to the change in the brain's electrical activity.

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Figure 2. Gain in detection threshold upon presentation of a tone with a 180 degree binaural shift (static is wide-band noise)



Key:

1. Curve 1 is the audio signal detection threshold plotted against signal frequency under normal conditions when the signal is transmitted simultaneously to both of the operator's ears.
 - a. diagram of normal signal input conditions.
2. Curve 2 is the detection threshold of this signal during phase shift of the signal input.
 - b. diagram of binaural shift in phase.
3. The hatched area shows the size of the "gain" obtained from this seemingly insignificant procedure. In the second case, evidently, additional mechanisms are included in the perceptual process--mechanisms linked to the human brain's hemispheric cooperation--which improves discrimination of incoming signals.
4. Left ear.
5. Right ear.
6. Decibels
7. KiloHertz

Figure 3 provides a fragment of the human brain's so-called slow variations of potential. Signal misses by the individual coincide with a drop, roughly speaking, in the brain's "voltage" which varies periodically.

Information display systems have traditionally been created basically by considering visual perception. The capabilities of the other sensory organs are not yet being used enough; however, each of them has its own special features whose use could have a significant impact. At times, signal redundancy (visual and auditory, auditory and tactile, etc.) is effective.

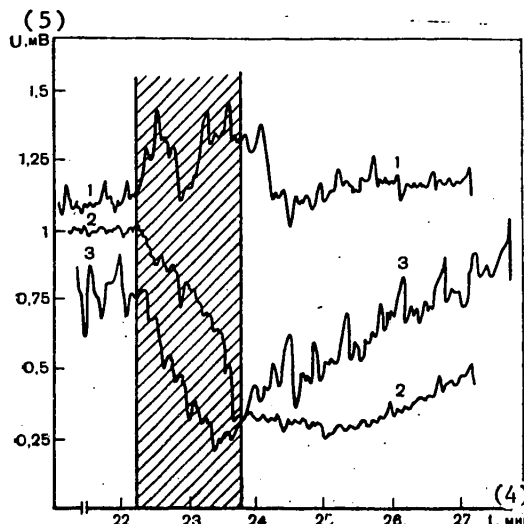
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Figure 3. Changes in brain wave potentials during a signal miss (hatched area).

Key:

1. Right temporal zone
2. Frontal zone
3. Left temporal zone
4. Time, in minutes
5. Voltage, in millivolts



Here's an example. The task of the operator controlling a system was to match one moving signal with another moving signal during a specified time. Both objects were only displayed on a visual display. With this method of information input, the operator correctly accomplished the task in only eight percent of the cases. Psychologists recommended that the visual signal be supplemented with an audio signal (with specially selected characteristics). As a result, the task was accomplished by the operator in 86 percent of the cases.

From psychology's point of view, here is another very important case--showing the operator the final results of his actions. It is the image of these results that "organize" the entire system of mental processes which control the individual's actions. It turns out that it is not so important for optimum task accomplishment to perceive the actual status of the object as it is to perceive its deviation from the desired status and to perceive the ultimate results of one's actions. In other words, the operator evaluates signals not in isolation but relative to the assigned task.

In the process of his work, the individual not only perceives but also stores and processes the information received. A significant number of mistakes occur because the proper information is not extracted from the individual's memory at a particular time or the perceived information is incorrectly deciphered.

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For a long time, there was an opinion in psychology that memory was a kind of homogeneous function, so to speak. However, experimental research has shown that it is necessary to indicate at least two information storage "units"--a short-term and a long-term one. Short-term memory is the retention of information just long enough to perform a particular, isolated act. As shown by experiments, the capacity of this memory is negligible; it is limited to 7 ± 2 units. Short-term memory is "delicate"; during strong emotional (stress) reactions, it can "malfunction"; that is, a strong emotion can "dislodge" the information stored in the memory. The individual can even "lose" the purpose of the act being performed. And this leads to chaotic movements and mistakes.

Let's give an example which testifies to the importance of considering the capacity of human memory when designing new equipment. To optimize pilot decision-making, a method of displaying information on the windshield was developed for several aircraft types. It was anticipated that this would free the pilot of the need to frequently shift his attention and would, thereby, ensure his uninterrupted visual spatial orientation. Fifteen values were put on the glass and, as is well known, this significantly exceeds the capacity of human short-term memory. As a result, flying accuracy declined, the error rate increased and pilot "malfunction" reaction time increased. A redesign of the information display based on data on perception, attention and memory made it possible to increase the accuracy of course cruising by 25 percent, it reduced pilot reaction time to an emergency signal by a factor of approximately 10, it freed additional time for observation (about 30 percent), etc. And, of special importance was the significant reduction in the pilot's emotional strain.

Information processing includes various aspects of the thinking process. It may take the form of operating with either ideas (operating with visual images) or with symbols or systems of symbols (in a logical, verbal form). In the operator's work, these aspects are integrated, sometimes rather uniquely. When the "man-machine" system is being developed, it is important to have a clear idea of what thinking operations the operator will have to perform and in what form he will have to perform them.

Anticipation, or predicting the course of events (advance reflection), is extremely important in the operator's work. Research shows that interruptions in the operator's work occur especially frequently when the opportunity for anticipation is hampered. This occurs when each of the operator's individual acts is strictly "regulated" by signals appearing at each specific moment, that is, when the individual is put in a "signal-response" operating mode.

The experimental data make it possible to talk about different levels of anticipation. The first level is the unconscious (subliminal level), the second is perception, the third is conception and finally, there is the level of thinking in words. Each of these levels has its own "resolution" or range of anticipation. It is important to note that the ability to anticipate makes it possible for the individual to

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function with a shortage of information and also to regenerate information which is broken up in transmission. Obviously, it is necessary to develop information display systems so that they provide the operator an ability not only for signal discrimination and identification but also for anticipation. Research conducted at the Institute of Psychology has shown that it is possible to rather actively manage the process of anticipation, that is, affect the efficiency of information processing by changing the individual's work environment and the methods of transmitting information to him.

The second group of psychological problems related to the task of matching equipment and industrial processes to the human operator's traits and abilities consists of an assessment of the mental "cost" of the actions being performed; in other words, what does the accuracy and speed of the action being performed cost the operator (in the sense of his mental strain). These are problems of the individual's mental states (especially the problem of so-called emotional stress).

At the Institute of Psychology, studies were conducted of the pilot's emotional state in case of an equipment malfunction during actual flight. It was established that in these cases the individual usually takes his bearings not by relying on instrument readings but by relying on his own direct sensations (which sometimes significantly hinders proper decision making). Moreover, the stress especially increases if the individual does not receive immediate information on the results of his actions.

Laboratory studies conducted at the Institute of Psychology have revealed a rather good correlation between the level of the individual's mental strain and the quality of his performance. This makes it possible to predict the quality of an operator's performance based on an evaluation of his mental state. Now, we are faced with the task of developing an automatic system for monitoring the individual's mental state. It will make it possible to continually track the dynamics of the individual's state and, depending upon the results, change, for example, the flow of information being directed to him, redistribute the workload between individual operators, vary the work rate or switch the information from one set of sensory organs to others.

The third group of psychological problems involve the task of operator selection and training. The accomplishment of these tasks must be based upon basic research on the individual psychological differences among people and on the principles for forming and developing vocationally important traits.

It is well known that there are extremely large differences among people in the statistics on perception, memory, thinking, emotional stability, peculiarities of spatial orientation, etc. Based on psychological research, several ways have taken shape of developing a typology of people based on their mental characteristics, that is, "dividing" them into specific classes, which significantly facilitates the task of selecting people for specific types of work.

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Let's look at one of the experiments which illustrates people's individual differences. The experiment describes differences in people's estimate of the spatial location of objects during a change in the gravitational effect. During the experiment (Figure 4), the subjects were located in a closed space for an extended period of time (the experiments were conducted on a yacht). The room that the subjects were in changed its position (for example, it was tilted at a particular angle). Under these conditions, the people had to accomplish different tasks. One of the tasks was for the subjects to put a rod into the vertical position by manipulating the handles.

Figure 4 shows the situation where the room was tilted at 15 degrees. During the experiments, it was established that some people took their bearings from gravitational signals (Line 1), others took them from visual signals, from the inside (Line 2), and still others "slipped" from one method to the other (Line 3).

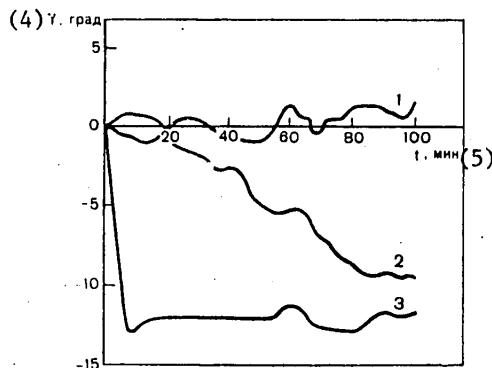


Figure 4. Spatial orientation experiment.

Key:

1. Gravity receptor dominance in determining positions of surrounding objects
2. "Drop off" of gravity receptor dominance
3. Visual dominance
4. Y-axis--mistakes in placing the rod in the vertical position (in degrees)
5. X-axis--time experiment conducted (in minutes)

The study of individual psychological differences among people is a necessary condition for a rational selection of them for specific types of work. Let's mention that until now this selection has frequently been based only upon an evaluation of the individual's physical health; meanwhile, it is people's psychological traits which are at least as important, if not more so.

At the Institute of Psychology of the USSR Academy of Sciences, studies are under way in this area and they are having a considerable impact. For example, the system of principles developed at the institute for vocational-psychological selection of entrants to special educational

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institutions made it possible to reduce the number of first-year dismissals by a factor of 2 and to improve the students' progress.

The hardest part of the job at present is finding effective methods of psychological diagnosis. For the future expansion of research to evaluate the individual's psychological features, the Institute of Psychology needs the assistance of interested parties.

But, the special selection of people for a specific type of work is only half of the job; these people still have to be trained. The acuteness of the training problem is dictated by the fact that the rates of equipment development are very high. Therefore, the development of methods for accelerated specialist training and retraining is especially important. This in turn presupposes a knowledge of the psychological principles for developing specific sets of vocationally important traits in the individual, specifically, developing vocational skills.

As shown by studies, the process of acquiring a skill is not simply "rote learning" of an action. During training, a reorganization of mental processes and their corresponding methods of acting takes place in the individual.

Figure 5 is a graph of operator training for the skill of working with a flow sheet. During a specific period of time, the operator must detect the disturbance and control it.

At first, the trainee works by components, as if scanning the flow sheet component by component. From trial to trial, the efficiency of his actions increases. But then the time arrives when there is a temporary decline in the efficiency of his actions. At that time, it seems that there is a reorganization of the operator's method of acting; he attempts to combine the components into groups and then to work with these groups. This reorganization makes it possible for him to increase the efficiency of his actions. Later, there is another slight drop in efficiency. It involves a new reorganization of the method of action: the trainee is beginning to "grasp" the entire situation as a whole--to operate simultaneously, which, in the final analysis, provides a further increase in the efficiency of his actions.

The reorganization of the individual's methods of acting and the reorganization of their related mental processes is a given, general law. It is very important to consider this reorganization during the training process in order to find procedures which will make it possible to accelerate the transition from one phase of training to another, more effective one.

The results of psychological research--results which are uncovering general and special laws of human mental processes and states, the common and individual human traits for receiving and processing information and also the change and evolution of the individual's vocational traits--is being used on a rather wide-spread basis in various fields of human performance and has a definite economic impact.

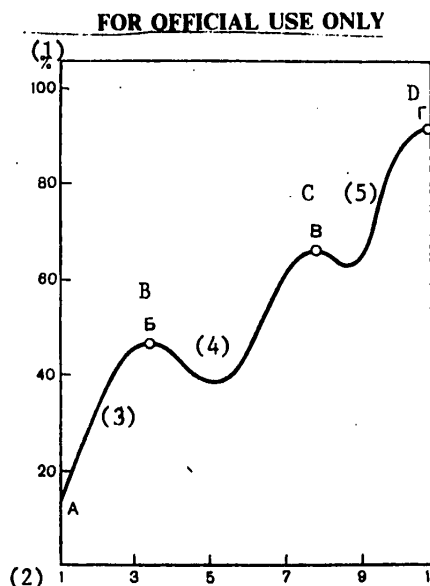


Figure 5. Graph of problem-solving training process (trouble shooting)

Key: 1. Y-axis--efficiency of operator's actions (or percentage of damage detected and corrected).
 2. X-axis--number of training sessions
 3. Segment A-B--operating by individual job components
 4. Segment B-C--operating by groups of components
 5. Segment C-D--operating by a simultaneous assessment (an assessment of the total situation).

But, the issue is not just one of economic impact; it is even more important that the problems being solved by psychologists are helping maintain people's mental health and capacity for work.

Here's a few words about the Institute of Psychology's plans and prospects for studying the problems listed. Members of the institute's staff will continue research on the problems of human information reception and processing. At the same time, plans call for more widespread development of the work to study problems involving human mental states and especially to establish the possibility of developing an automated inspection of these states. We will also study people's individual psychological differences and training principles. It is especially important to accelerate research in the field of psychological diagnosis (this is one of the lagging areas in Soviet psychology).

There are plans to develop an automated system for psychological experiments. Mental processes are very complex phenomena which are affected by a great many, diverse factors. Therefore, a major obstacle is presented by the processing of numerous and frequently contradictory facts. In addition, during the research process, there are numerous complex tasks which require particular modifications during the course of an experiment. All of this dictates the requirement for an automated system, one which it will be difficult for psychologists to do without.

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Overall, research on human performance within "man-machine" systems is a good field for integrated studies which may bring together specialists from the social, natural and engineering sciences.

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The speaker responded to questions from Academician S. N. Vernov on the enhanced "psychological compatibility" between computers and their operators; from Academicians Ye. P. Velikhov and P. O. Kapitsa on the study of psychological problems involving the design of control systems for various processes (specifically, the development of an automated monitoring system for the human brain's bioelectrical performance) as well as techniques for optimum human "collaboration" with automated systems; and from Academician M. A. Markov on the level of accuracy of data obtained from psychological research.

In opening the discussion, Academician P. N. Fedoseyev, vice-president of the USSR Academy of Sciences, suggested that a special resolution be adopted on B. F. Lomov's scientific report, a resolution which would highlight the basic areas of psychological research on the problems of the man-equipment interface. It is necessary to do this because the problems raised in the report are very important and urgent ones but the solution to many of them is still in the initial stages. The goal of the present discussion at the USSR Academy of Sciences Presidium was precisely to speed up this research.

P. N. Fedoseyev made the following suggestions.

Recognize the need to increase research on problems involving operator performance on up-to-date equipment.

Concentrate the efforts of scientists primarily on solutions to the most important problems, such as, the human processes of receiving, storing and processing information, scientific principles of operator selection and training, the dynamics of human mental states and the psychological aspects of joint operator performance.

Set up integrated studies of these problems with the participation of physiologists and specialists in human genetics, social psychology and sociology. Commission the Institute of Psychology of the USSR Academy of Sciences, along with the Academy's departments of physiology and biology and institutes of sociology, and the Academy of Educational Sciences to develop concrete proposals on the organization of integrated research.

Improve the supply of the Institute of Psychology's technical equipment: provide assistance in developing special equipment to conduct psychological studies. To this end, commission the Institute of Psychology to prepare concrete proposals and commit the appropriate academic organizations to provide assistance to the institute.

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Support the Institute of Psychology's initiative to establish psychological problem laboratories, groups and institute branches during 1981-1982: on psychological diagnosis in Yaroslavl', on applied psychology in Gor'kiy and on measurement of human operator psychological performance in Saratov.

It is also necessary to express the desire that the USSR Ministry of Higher and Secondary Specialized Education examine the issue of establishing departments at leading institutes of higher engineering education to train specialists in the field of engineering psychology.

Academician A. P. Aleksandrov, president of the USSR Academy of Sciences, pointed out that in the development of power plant control systems, there are rather frequent difficulties involving the fact that the psychological aspects of the complex equipment operator's actions have not yet been studied, recommendations have not yet been made, and experience which could be applied has not been stored up. This forces us to build very complex simulators, but even this does not always have positive results.

For example, when routine information on plant status was "supported" by emergency warning signals providing evidence that certain parameters exceeded the norm and it was necessary to turn the plant off, the operators did not react to these signals rather frequently. This was specifically accounted for by the fact that the particular monotony of monitoring plant operations at the control console led to a short "failure" of operator perception (sometimes, it even led to dozing), to a situation where the operator did not completely perceive the signal. The visual signal had to be "reinforced" with an audio signal. But, even in this case, the operator was not able to immediately "plug into" the work rhythm accurately; he began to act hastily and, as a result, made quite a lot of mistakes. This finally made it necessary to change over to a system where the operator was used in such a manner that he did not affect the plant directly but through a plant operating mode selector (that is, the operator only sets the goal and the automatic equipment itself "selects" the proper procedure for changing plant operations from one mode to another).

In this respect, the question arises: wouldn't it be simpler to eliminate the individual altogether from any participation in the plant control process and just leave the machine? This question also concerns automated monitoring of human mental states--after all, this is by no means an easy problem. In the final analysis, it turned out that it was more advantageous (and more reliable) to retain a system of control with human participation, where the individual can duplicate the response to an emergency signal. However, it is necessary to emphasize that finding an optimal solution in the development of the "man-equipment control" system is a very difficult, delicate problem.

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During the investigation of the circumstances of one of the last mishaps at the American Three-Mile Island nuclear plant, for example, it was revealed that such an "avalanche" of signals "fell upon" the operator at the time of the accident that he was not able to make the proper response to them (in his words, the abundance of signals brought him to such a state that he wanted to blow-up the panel). When we developed the control console where principles of symmetry were observed (right and left consoles with their mirror displays of each other), this led to incessant operator errors. It turned out that it was more advisable to make not mirror displays on the consoles but a sort of copy of each of them.

These examples attest to the critical need for serious psychological analysis of all feasible control systems and the development of concrete recommendations to design optimal models of them, considering the special features of human perception and response. This is one of the major goals of the Institute of Psychology. It is precisely in this area that the institute should closely review its plans for scientific work and select the most important and critical research areas.

I think it is necessary to concur with P. N. Fedoseyev's proposal and adopt a special resolution on B. F. Lomov's scientific report.

Academician V. S. Semenikhin talked about the need for solving the range of problems involving control of modern automated systems where the operator has to process hundreds of reports within a very short period of time. This is the aspect that has been worked on the least right now, he emphasized. We need recommendations which are not based on intuition but on concrete, in-depth psychological research which would help the operator extract from the enormous flow of information that which is required for decision making.

On A. P. Aleksandrov's remark that the development of such a system will evidently require preliminary processing of information and input of it in a form where the operator is faced with alternative decisions and is shown the results of his actions, V. S. Semenikhin stated that, even in this case, there were still a lot of subjective cases of an intuitive approach to an assessment of the situation. In order to make the task more concrete for the designers of control systems, he noted, it was necessary to have a knowledge of the laws based on psychological studies of human capabilities.

A. P. Aleksandrov pointed out that, in his opinion, alternative formulations of the problems were also possible (formulations which, perhaps, were sometimes not very well supported but which were the more effective of those available). These possibilities should also be considered.

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In the decree it adopted, the Presidium of the USSR Academy of Sciences noted the need to increase research on the performance of the operator of modern equipment, while devoting special attention to the development of psychologically warranted recommendations which will make it possible to build technical devices guaranteeing a high degree of efficiency of control equipment. It cited the most important and urgent problems upon which the efforts of psychologists should be concentrated.

The advisability of establishing integrated research in the fields of human psychology, physiology and genetics as well as education and sociology was emphasized. To these ends, the USSR Academy of Sciences Institute of Psychology, in conjunction with the Academy's Department of Physiology, Department of General Biology, Department of Philosophy and Law, as well as the USSR Academy of Pedagogical Sciences, should develop concrete suggestions to organize integrated research.

Instructions were issued to take steps to equip the USSR Academy of Sciences Institute of Psychology with the equipment required to develop a system for automated psychological experiments. The USSR Academy of Sciences Institute of Psychology, in conjunction with the Academy's Council on Scientific Instrument Engineering and the Academy's Engineering Association, were commissioned to prepare recommendations on the design of special equipment to conduct psychological research.

The Academy's social science sections and Department of Philosophy and Law were commissioned to prepare for review by a session of the Presidium of the USSR Academy of Sciences the issue of setting up laboratories of the branches of the Institute of Psychology: on psychological diagnosis in Yaroslavl', on applied psychology in Gor'kiy and on measurement of the human operator's psychological characteristics in Saratov.

It was recommended to request the USSR Ministry of Higher and Secondary Specialized Education to review the issue of developing special departments in the country's leading institutions of higher engineering education to train specialists in engineering psychology.

Followup on performance of this decree is assigned to the Social Sciences Section of the USSR Academy of Sciences Presidium.

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FUNDAMENTALS OF MILITARY PSYCHOLOGY AND EDUCATION SCIENCE

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Brief Description:

This textbook presents the main points of Soviet military psychology and education science in conformity with the curriculum at higher command and engineering schools. Advice and recommendations on teaching and training enlisted personnel and non-commissioned officers are presented on the basis of practical experience in combat and political training of Soviet Armed Forces personnel. This textbook is intended for personnel enrolled at higher command and engineering schools. It can be recommended to officers of military units and naval ships, as well as to persons enrolled at party schools.

INTRODUCTION

The Soviet Armed Forces are called upon reliably to defend the socialist homeland and to maintain a continuous state of combat readiness guaranteeing an immediate rebuff to any aggressor.

An important feature of the contemporary development of the USSR Armed Forces is a continuous improvement in their technical equipment. V. I. Lenin considered this to be one of the main indicators of the defense capability of the state. "The very finest army and persons most dedicated to the cause of the revolution," he stated, "will be immediately annihilated by the enemy if they are inadequately armed, provisioned, and trained."¹ The Communist Party of the Soviet Union rigorously follows these Lenin precepts.

Attaching great importance to technical equipment of the USSR Armed Forces, the CPSU at the same time has always believed and continues to believe that weapons can be a powerful means of national defense only if army and navy personnel are deeply aware of their great responsibility to the homeland and possess a consummate mastery of their weapons. "A solid fusion of a high degree of technical equipment, military expertise and indomitable morale -- this is the fighting potential of the Soviet Armed Forces,"² stressed L. I. Brezhnev in the CPSU Central Committee Accountability Report to the 26th CPSU Congress. For this reason the party devotes unrelenting attention to training and indoctrination of Soviet military personnel and increasing the combat readiness of the USSR Armed Forces.

Demands on the content, quality and effectiveness of work in the area of Communist indoctrination of Soviet servicemen have increased in present-day conditions. CPSU

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decisions have stressed time and again that the heart of ideological and political indoctrination work has been and remains formation in Soviet citizens of a scientific philosophical outlook, total dedication to the cause of the party and Communist ideals, a love of the socialist homeland, and proletarian internationalism. Also of great importance in indoctrination of personnel is development of a vigorous political attitude, total dedication to the military duty, a high degree of discipline, political vigilance, hatred toward imperialism, readiness and willingness to come to the defense of the homeland at all times.

In order to accomplish these important tasks of Communist indoctrination of Soviet citizens, army and navy personnel, the CPSU Central Committee considers it essential continuously to raise the scientific level of ideological and political indoctrination work, further to strengthen its bond with practical realities, and to develop the aggressive character of the indoctrination process.

Officer cadres play the principal role in development of the Soviet serviceman and in ensuring the continuous combat readiness of the USSR Armed Forces. Officer cadres train and indoctrinate army and navy personnel and direct the daily activities of their subordinates.

Troop training and indoctrination are organized and conducted on a scientific basis. V. I. Lenin emphasized that a modern army cannot be built without science.³ These words ring particularly true today. "Soviet military science," notes USSR Minister of Defense Mar. SU D. F. Ustinov, member of the CPSU Central Committee Politburo, "reliably serves, as it always has, the cause of practical accomplishment of the tasks facing the Armed Forces."⁴

Military psychology and military education science play an important role in training and indoctrination of personnel.

Military psychology studies the laws and patterns of development and manifestation of the psychological features of the individual serviceman and military collectives in conditions of peacetime and wartime. Military education science investigates the essence, content, laws and patterns of training and indoctrination of servicemen and military collectives. It substantiates the principles, forms, methods and means of training and indoctrination of servicemen and military collectives. Working in close coordination, military psychology and military education science elaborate the conditions and ways of effectively influencing the consciousness and behavior of military personnel for the purpose of forming excellent moral-political and fighting qualities in these personnel.

Military psychology and education science incorporate advances made in many sciences dealing with man, the collective, their labor and combat activities.

Military psychology and pedagogy as sciences are closely linked with the theory and practice of party-political work. At the same time party-political work in the military produces fine, positive results if it is performed taking into account the laws and patterns revealed by military psychology and education science. Army Gen A. A. Yepishev, chief of the Main Political Directorate of the Soviet Army and Navy, notes that "successes in combat, moral-political and psychological training of personnel are due to a significant degree to the fact that their activities are

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grounded on scientific theory and practice of party-political work and take into account the points and conclusions of Soviet military psychology and education science."⁵

Profound mastery of military psychology and education science is a serious matter. In order successfully to train and indoctrinate his subordinates, it is not enough for an officer to possess a certain sum total of knowledge which he acquires at military educational institutions and in independent study of the literature. As is indicated by practical experience, he must develop in himself a psychological-pedagogic mode of thinking -- the ability to think in terms of psychology and education science in accomplishing training and indoctrination tasks and in daily supervision of his men, just as he thinks, for example, in the terms and concepts of tactics in solving tactical problems.

This textbook will assist future officers in this. It contains a systematized presentation of military psychology and military education science in conformity with the curriculum for higher military schools and reveals the fundamental psychological-pedagogic laws and patterns forming the foundation of successful service and combat activity of military personnel, the essence, forms and methods of training, indoctrination and moral-psychological preparation of personnel, cohesion of military collectives, strengthening of discipline and combat readiness of units and subunits.

Knowledge of military psychology and education science is transformed into firm concepts and ideas, into a psychological-pedagogic mode of thinking only when the student systematically assimilates the curricular material and thoroughly understands theoretical content and practical significance. This is promoted by the student thoroughly thinking through each and every lecture, independent study of the recommended literature, as well as regular, well-prepared presentations at seminar classes.

The habit of reading on a regular basis newly-appearing works on military psychology and education science, active participation in a military psychology and education science study group, and systematic reading of war memoir literature, which contains a wealth of experience in training, indoctrination and guidance of the activities of personnel during the years of the Great Patriotic War -- all this helps gain a better understanding of the service performance, combat activities and daily life of personnel, as well as training and indoctrination tasks assigned to Soviet Army and Navy officers, and helps understand the essence of a psychological-pedagogic approach to accomplishing them. Very helpful in mastering military psychology and education science is viewing and discussion, from the standpoint of psychological-pedagogic science, of training and feature films dealing with the life and activities of Soviet servicemen.

A decisive role in mastering curricular material on military psychology and education science is played by practical application of knowledge obtained on these subjects and work with personnel during a tour of duty in line units, in daily training and service activities.

Vigorous and systematic independent work by cadets and young officers in order to master military psychology and education science will produce the desired results --

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military-psychological and pedagogic knowledge will be transformed into their personal views, into a system of psychological-pedagogic thinking. And this is the foundation of effective, genuinely innovative work in the area of training and indoctrinating subordinates and guiding their activities.

FOOTNOTES

1. V. I. Lenin, "Poln. Sobr. Soch." [Complete Works], Vol 35, page 408.
2. L. I. Brezhnev, "Otchetnyy doklad Tsentral'nogo Komiteta KPSS XXVI s"yezdu Kommunisticheskoy Partii Sovetskogo Soyuza i ocherednyye zadachi partii v oblasti vnutrenney i vneshney politiki" [Accountability Report of the CPSU Central Committee to the 26th Congress of the Communist Party of the Soviet Union and Current Party Tasks in the Area of Domestic and Foreign Policy], Moscow, 1981, page 89.
3. See Lenin, op. cit., Vol 40, page 183.
4. D. F. Ustinov, "Izbrannyye rechi i stat'i" [Selected Speeches and Articles], Moscow, 1979, page 321.
5. A. A. Yepishev, "Ideologicheskaya rabota v Sovetskikh Vooruzhennykh Silakh" [Ideological Work in the Soviet Armed Forces], Moscow, 1979, page 139.

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